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AI and Education: Building the Future Through Digital Transformation

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Inter-American Development Bank
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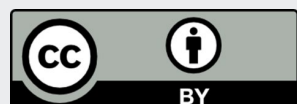
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Abstract

For decades, technology has been promoted as a solution to educational challenges in Latin America and the Caribbean, with early enthusiasm suggesting that digital tools could revolutionize access and learnings. However, real-world implementation has revealed mixed results, with a lack of pedagogical integration and infrastructure hindering their impact. As artificial intelligence (AI) emerges as the next frontier in education, the digital transformation of education presents both opportunities and risks. This tension raises an urgent question: can AI become the transformative force it promises to be, or will it face the same challenges that have hindered previous technological innovations?

The answer will depend not only on technological advancements, but also on the quality of research, critical evaluation, and the thoughtful implementation and monitoring of policies accompanying AI's integration in education. By synthesizing lessons from previous experiences and addressing the emerging uncertainties surrounding AI's role in education, this study offers policymakers practical, evidence-based recommendations. It presents a framework to guide the effective integration of technology in education, providing a structured approach to setting objectives, articulating a theory of change, and identifying the key components needed for successful program implementation.

Ultimately, the goal is to ensure that AI and other digital technologies are not integrated for their own sake, but are deployed in ways that lead to measurable improvements in educational quality, equity, and efficiency across the region.

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1. Introduction

For decades, technology has been heralded as the key to solving educational challenges, particularly in developing regions like Latin America and the Caribbean (LAC). In the 1990s and 2000s, mainstream media, academia and influential think tanks fueled an almost utopian vision of digital learning, portraying technology as a tool that could “leapfrog” traditional barriers and revolutionize access to education. Scholars and policymakers alike championed the idea that Information and communication technologies (ICT) would democratize knowledge, improve literacy rates and empower students across the region.



Ultimately, the goal is to ensure that AI and other digital technologies are not just integrated for their own sake but are deployed in ways that lead to measurable improvements in educational quality, equity and efficiency across the region.



However, as implementation progressed, real-world evidence began to challenge this initial enthusiasm. By the late 2000s and early 2010s, academic evaluations and policy analyses started revealing the limitations and unintended consequences of large-scale educational technology (ed-tech) initiatives. Studies on the One Laptop Per Child (OLPC) program, for instance, showed little to no improvement in student learning outcomes, with many devices left unused due to a lack of teacher training, poor infrastructure and limited internet access. Critical assessments have shown that without pedagogical integration, technology alone was insufficient to improve educational quality. Media narratives also began shifting, questioning whether ed-tech solutions were overhyped, and whether they had underdelivered. In all, these assessments found that technology, while valuable, is not a silver bullet for deep-rooted educational inequalities.

Now, the emerging potential of artificial intelligence (AI), particularly popular generative AI tools available since 2022, confront educators and policy makers with a paradox. On one hand, AI promises personalized learning, automated assessments and data-driven educational improvements at scale. On the other hand, concerns about equity, bias and the uncritical adoption of AI in education remain significant. Without rigorous evaluation and careful integration, AI risks repeating the same cycle that characterized past ed-tech solutions. This tension raises an urgent question: can AI become the transformative force it promises to be? Or will it face the same challenges that have hindered previous technological innovations? The answer will depend not only on technological advancements but also on the quality of research, critical evaluation, thoughtful policy implementation and monitoring that accompanies AI's integration in education.

Building on the lessons learned from past ed-tech initiatives, this note seeks to: 1) critically examine the empirical evidence of technology's effectiveness in education; and 2) develop a framework to ensure that the digital transformation of education (DTE) is driven by clear, outcome-driven objectives. While technology has demonstrated clear benefits in certain contexts, its impact is highly dependent on implementation conditions, pedagogical integration and systemic support. Simply introducing digital tools is not enough. Technology must be used strategically if it is to help address the most pressing challenges facing education systems in Latin America—enhancing learning outcomes, improving access and completion rates, and increasing overall system efficiency. However, it is essential to recognize that the DTE should not merely focus on technology itself, but rather on transforming educational practices. Technology must be integrated as a tool to enable deeper changes in teaching and learning, such as enhancing project-based learning through digital platforms, which leads to a more profound impact (OECD, 2021). The successful adoption of digital tools hinges on creating a systemic shift in educational models, where technology supports broader pedagogical and organizational reforms.

By defining a framework for how technology should be integrated into education, this study provides a structured approach to defining objectives, establishing a theory of change, and identifying the necessary elements of successful program implementation. By synthesizing lessons from previous experiences and addressing the emerging uncertainties around AI's role in education, this study offers policymakers practical, evidence-based recommendations. Ultimately, the goal is to ensure that AI and other digital technologies are not just integrated for their own sake but are deployed in ways that lead to measurable improvements in educational quality, equity and efficiency across the region.

Following this introduction, Section II provides a thorough review of the literature on how technology can help achieve educational goals in LAC. The section focuses on three key policy goals: 1) maximizing learning in the classroom; 2) expanding access and the achievement of complete learning trajectories; and 3) efficiency in service delivery. In Section III, we address the emerging opportunities and challenges associated with AI adoption. This section analyzes how AI technologies can transform the three key policy goals previously mentioned, while also considering risks and ethical implications that may arise. Section IV develops a conceptual framework for the effective integration of technology in education. As such, this section highlights the importance of five enabling conditions for the effective and sustainable digital transformation of technology: digital devices, meaningful educational connectivity, digital content, teacher competencies and governance. It also outlines different pathways education systems can take to navigate the digital transformation of education in a strategic manner. These pathways are informed by lessons learned and an evidence-based approach. Section V concludes the report by synthesizing its key findings and core messages.

2.

Harnessing
technology to
achieve educational
goals in LAC



Technology should be a means to an end, not the goal itself. To be effective, technology must be deployed strategically to address specific educational challenges and achieve well-defined objectives. The first and most crucial step in integrating technology is identifying the precise learning or education management need that requires attention. Once the goal is established, the next step is determining



To be effective, technology must be deployed strategically to address specific educational challenges and achieve well-defined objectives.



which processes technology can enhance based on the unique advantages it can offer. While technology in education also plays a broader role in equipping individuals with the skills needed to navigate a digital world, its implementation must be purpose driven. As societies and economies become more reliant on digital technologies and artificial intelligence, education systems must prepare individuals not only to use technology effectively but also to critically assess, adapt and create with it. However, this broader imperative does not replace the need for a strategic approach to technology integration within education systems. The challenge is not merely to incorporate technology but to do so in ways that effectively support teaching, learning and school management. Without a clear purpose, technology risks becoming an end in itself rather than a tool for meaningful transformation. This would mean missing the opportunity to address concrete educational needs and contribute to more equitable and effective learning environments.

Globally, technology has been used to tackle challenges such as reducing teacher absenteeism, enabling personalized instruction and scaling the distribution of learning resources. While the effectiveness of these interventions varies—particularly in low- and middle-income contexts—research highlights the types of technologies and programmatic features most likely to support positive outcomes.

This section examines key educational challenges in Latin America and the Caribbean (LAC) and identifies three overarching policy goals where technology can make a meaningful impact: 1) maximizing learning in the classroom; 2) expanding access and achieving complete learning trajectories; and 3) enhancing efficiency in service delivery. These goals are not rigid categories but rather a structure for analyzing real-world examples and drawing lessons from empirical evidence on the role of technology in education.

Challenge 1: Low and unequal learning outcomes

> Policy goal: Maximizing learning in the classroom

Learning outcomes in LAC remain alarmingly low. According to PISA 2022, three out of four students in LAC do not reach proficiency in mathematics, and nearly half lack basic reading skills (Arias Ortiz et al., 2023). The learning gap between LAC and OECD countries is equivalent to five years of schooling, while top-performing systems like Singapore are nearly a decade ahead. Socioeconomic disparities further deepen this crisis, with students from the lowest income quintile facing a learning gap of almost four years compared to their more advantaged peers (Arias Ortiz et al., 2024a). Addressing this challenge requires a strong focus on improving learning experiences in the classroom. It also requires ensuring that teaching practices and curriculum design enhance student performance while also fostering digital skills and the ability to learn effectively in digital environments.

Challenge 2: Low enrollment and high dropout rates in secondary and tertiary education

> Policy goal: Expanding access and achieving complete learning trajectories

While primary education coverage is nearly universal across LAC, only 80% of young people enroll in secondary education, with an 11-percentage-point gap between the lowest and highest income quintiles (Arias Ortiz et al., 2024a). Dropout rates remain a critical issue, with 27% of students leaving school before completing secondary education. A key factor behind this trend is a lack of engagement—20% of those who drop out cite an unappealing curriculum and uninspiring teaching methods as primary reasons (Arias Ortiz et al., 2024a). Access to higher education is even more limited, with only 30% of young people enrolling. Socioeconomic disparities further restrict opportunities: just 16% of students from the lowest income quintile enter higher education, compared to 45% from the highest quintile. Expanding access and engagement in order to promote more complete learning trajectories throughout the cycle and beyond is crucial to ensuring equitable educational pathways (Arias Ortiz et al., 2024a).

Challenge 3: Low efficiency of education investment in relation to learning outcomes, and inefficiency and inequity in resource allocation

> Policy goal: Efficiency in service delivery

The effectiveness of education systems depends not only on financial investment but also on how resources are allocated and used. Countries like Vietnam and Turkey, where investment in education (in USD) is similar to LAC nations, significantly outperform the region in mathematics, suggesting that factors beyond spending levels contribute to better educational outcomes (OECD, 2023). LAC countries face several inefficiencies, including poor data quality on learning outcomes, inequitable distribution of teachers and resources, and inadequate infrastructure planning. Many education systems lack reliable and timely data to guide decision-making, limiting their ability to track progress and design effective policies. The unequal allocation of teachers and resources further deepens disparities, as disadvantaged schools frequently struggle with a shortage of qualified educators and essential learning materials (Aguilera et al., 2023). Additionally, deficiencies in infrastructure planning result in overcrowded classrooms in some areas and underutilized facilities in others, which undermines the efficiency of educational investments. Addressing these inefficiencies created by weak governance and investment is essential to enhancing both the effectiveness and equity of education systems across the region.

Technology can be a powerful tool to support these policy goals, but its implementation must be evidence-based and purpose-driven. The following section presents a comprehensive review of the latest and most rigorous research on how technology can effectively address the specific challenges faced by countries in the region.

2.1

How can technology help? A review of the evidence

A. Maximizing learning in the classroom

Evidence suggests that when technology is coherently integrated into teaching and learning practices, it can significantly enhance the role of teachers and improve learning outcomes. Coherently integrated technology can bring about these outcomes through better instruction and individualized learning practices. Well-integrated technological interventions can be especially efficient for teachers who have to manage large class sizes and a wide range of proficiency levels within the same class, as personalized attention is harder to achieve in these contexts (see Box 1). These interventions usually provide integrated support for teachers to improve both the content and pedagogy of their teaching practices (see Box 2).

While education technology can be effective when properly designed and implemented according to a specific context (Rodriguez-Segura, 2022), success depends on a coherent integration between digital infrastructure and pedagogical practices. Solely providing hardware and connectivity in isolation has often been costly and ineffective in terms of directly improving learning outcomes (Banerjee et al., 2023). However, when proper hardware and meaningful educational connectivity are in place, well-designed, technology-based education strategies grounded in clear pedagogical frameworks can serve as valuable complements to the role teachers play in achieving higher learning outcomes.

Customization to address varying learning levels

One of the most promising technological interventions in education focuses on enabling students to learn at their own pace. In particular, this type of technological intervention can improve learning outcomes in environments where classroom instruction may not meet individual needs due to high pupil-teacher ratios or short instructional periods.

Box 1. The challenge of intra-class heterogeneity

Many countries around the world have seen a significant increase in school enrollment over the past decades. In Latin America and the Caribbean, net primary school enrollment rose from 83% in 1980 to 94% in 2018, an increase of nearly 20 million more students enrolled in primary education in the region (World Bank, 2024ab). This progress, along with a decline in the pupil-teacher ratio in primary schools from 32 to nearly 20 pupils per teacher over the same period, reflects a laudable policy commitment to achieving universal enrollment, particularly at the primary level.

At the same time, this expansion has also brought many students into the education system who may have been excluded prior. These students often hail from lower socioeconomic backgrounds, and some are the first in their families to go to school. The inclusion of students with these backgrounds increases intra-class and intra-school disparities in learning outcomes (Ganimian and Djaker, 2023). Greater intra-class heterogeneity, in turn, makes it harder for teachers to reach most students through traditional, one-size-fits-all classroom instruction (Duflo et al., 2011). This can be especially true if teachers are incentivized, either explicitly or more subtly, to focus on high-performing students rather than the entire class. In these cases, an environment can develop where only top students benefit from classroom instruction, which further exacerbates inequalities. Additionally, while average pupil-teacher ratios in LAC have improved in recent decades on average, in schools where there are still large class sizes, intra-class heterogeneity can make it even more difficult for teachers to adapt their instruction and support students across a full range of proficiencies.

Central to this approach is the use of adaptative learning technologies, which assess students' proficiency levels and pace of progress, and adjust the level of difficulty accordingly. This adaptability has been a key component of several successful interventions (Banerjee et al., 2007; Muralidharan et al., 2019; Ito et al., 2019; Carrillo et al., 2010). In classrooms with wide achievement gaps, adaptability allows students to work at their own pace and engage with content suited to their abilities, which promotes meaningful progress for learners of all skill levels. These interventions typically include computer-assisted instruction (CAI), integrated into classroom curricula, and computer-assisted learning (CAL), which operates independently of teacher-led instruction (Bai et al., 2016)².

While there are potential benefits of features like adaptability, there is relatively less evidence around other design features. Design features with less evidence include dosage (the amount of time and frequency with which students use technology in the classroom), the optimal degree of customization, and the exact type of use during the learning process.

In terms of dosage, for example, the expected student usage varies significantly in the literature. Studies have examined different durations of student technology use per session, from 20 minutes (Beg et al., 2022) to 90 minutes (Araya et al., 2025). The literature also shows differences in the frequency of expected student

² Computer-assisted instruction (CAI) refers to the use of technology, often computers, to deliver specific instructional content or to guide students through lessons or exercises. It is closely aligned with teaching objectives, using technology as a teaching tool to support and enhance the educational process. Examples include tutorials designed to teach specific topics in mathematics or languages, as well as simulations that illustrate and explain scientific phenomena.

On the other hand, computer-assisted learning (CAL) encompasses a broader concept where computers are used as tools to facilitate the overall learning process. It may involve independent exploration, research or activities that go beyond structured instruction. Examples include multimedia resources, such as videos or interactive simulations for self-directed learning, research tools like online libraries, or educational software used for project-based learning.

usage, from twice a week (Lai et al., 2016) to six times a week (Muralidharan et al., 2019). On the one hand, a study in Russia found that doubling the duration of a student-facing intervention did not significantly enhance learning (Bettinger et al., 2023). Conversely, among the interventions reviewed for this technical note, those that involved students engaging directly with a platform that led to positive effects generally required at least 25–30 minutes of daily engagement. According to PISA 2022 data, while the use of digital devices for learning activities at school shows some association with higher mathematics scores, excessive use—particularly over five hours daily—was linked to lower performance (OECD, 2023). Therefore, while increased usage of a technological platform does not necessarily result in higher learning outcomes, a minimum amount of dosage is required to achieve positive results, as superficial engagement of a few minutes is unlikely to yield meaningful outcomes.

To determine the appropriate dosage for a given intervention —how much time students should spend engaging with these tools— it is critical to consider both the materials’ design and the “opportunity cost” for students (e.g., whether it detracts from classroom instruction or occurs after school). For instance, a study in India found that software that helped improve learning outcomes in an after-school setting (Muralidharan et al., 2019) did not produce higher learning outcomes when used in school—among other differences—though it did improve the assessed mathematics scores of lower-performing students (de Barros & Ganimian, 2024). This suggests that the gains observed in Muralidharan et al. (2019) may have been partly driven by the addition of time on task rather than the replacement of in-school time. Overall, while research on dosage is limited, existing evidence suggests that: 1) simply increasing time spent on learning platforms does not necessarily improve learning outcomes; 2) a minimum level of deep engagement, typically involving sessions of at least 20–30 minutes, is likely required to achieve positive effects; and 3) a localized understanding of what students would be doing in the absence of the intervention is essential for assessing its true impact.

Another feature to consider is the level of customization of the platform. Developing sophisticated assessment software, particularly with adaptive features, requires significant investment in building extensive item banks, databases and algorithms capable of precisely tailoring content to students’ performance levels. That said, not all additions to ed-tech products that facilitate practice are beneficial. For example, a study in India found that adding independent practice at the end of software modules (de Barros et al., 2022) had on average, no effect after six months of treatment. In such cases, the platform’s design could function effectively without these practice modules, potentially streamlining the user experience. Identifying the most effective level of adaptability and practice for self-led or nearly self-led interventions is, therefore, essential for maximizing the efficacy of technology-based tools, while also balancing their development costs and complexity.

Finally, student-centered interventions must be easy to engage with and navigate for all students in the target group, as students often interact with these tools independently or with minimal assistance. If the platform is overly complex or requires multiple steps to set up, lower-performing students may struggle to keep up, potentially widening the gap between them and their higher-performing peers (Carrillo et al., 2010; He et al., 2008). To ensure that all students can benefit, the right balance of adaptability and dosage must be struck, particularly as these tools are integrated into classroom instruction. While guidelines for optimal dosage may be provided, teachers play a crucial role in adjusting time and frequency depending on the needs of their students and the context of the classroom. By optimizing these elements, technology-based interventions can more effectively support diverse learners and help close achievement gaps.

● Shaping classroom-based instruction

Beyond directly targeting students through customization, technology has enabled teachers to change how lessons are planned, structured and delivered. In some cases, this has successfully complemented, rather than replaced, the role of teachers, leading to stronger learning outcomes. For instance, research shows that when computer-assisted instruction is seamlessly integrated into the instructional process, it offers more consistent benefits compared to other methods (Bai et al., 2016; Lai et al., 2013, 2015, 2016; Mo et al., 2014, 2015). Conversely, efforts aimed at fully replacing teacher instruction may not lead to higher learning outcomes, even if they do affect other aspects, such as student attitudes towards academic learning (Ferman et al., 2019; Linden, 2008).

Box 2. The challenge of limited teacher content knowledge and pedagogical skills

Teacher aptitude, teaching capacity, effort and content knowledge play an important role in student achievement (Chetty et al., 2014). As such, effective classroom instruction relies on teachers' mastery of subject matter (i.e. their content knowledge) and teachers' ability to teach it properly (i.e. pedagogical skills). If either of these elements is weak, students may receive inaccurate information or experience poorly delivered lessons, which can in turn disrupt their learning process. Conversely, strong content knowledge and effective teaching practices are essential for fostering improved educational outcomes (Angrist et al., 2023b; Gess-Newsome et al., 2019).

In Latin America, evidence suggests that deficiencies in these areas are a concern. For example, a study conducted in Paraguay, the Dominican Republic and Nuevo León, Mexico found that less effective teaching practices like "drill and practice" and memorization remain prevalent in classrooms (Näslund-Hadley et al., 2014b). The same research indicated that pedagogical approaches encouraging deeper cognitive engagement could lead to better performance on international assessments. Additionally, there is evidence that on average, teachers in the region demonstrate lower cognitive and numeracy skills compared to individuals with other tertiary degrees backgrounds (Estrada & Lombardi, 2023). Therefore, interventions that address gaps in content knowledge or improve teachers' instructional practices may be essential for raising learning outcomes in the region.

Complementing classroom instruction with technological content that aligns with and enhances what is taught in class can be effective. Studies conducted in Pakistan, Paraguay and India (Beg et al., 2022; Näslund-Hadley et al., 2014a; Wennersten et al., 2015) examined the impact of pre-recorded content designed to complement classroom teaching. In Pakistan, the study provided expert content tailored to the local context, which complemented regular class time and equipped teachers with tools to review video content through multiple-choice assessments, particularly on topics they might not be experts in themselves (see Box 2). Similarly, the intervention in Paraguay featured pre-recorded lessons that adhered to the national math curriculum for preschool, taught bilingually in Spanish and Guaraní to reflect local teaching conditions.

Further evidence suggests that empowering teachers with high-quality instructional materials and lesson plans via structured pedagogy programs delivered remotely can improve learning outcomes. Studies conducted in Senegal, The Gambia and Kenya (Blimpo et al., 2020; Lehrer et al., 2019; Gray-Lobe et al., 2022) found that providing technology with features like lesson scripts boosted test scores. The comprehensive programs in Senegal and Kenya improved access to technology for both teachers and

students while enhancing instructional methods and student engagement. Although researchers were unable to isolate the individual effects of each component, including technology, the studies highlight how technology can empower broader educational reform, including stronger pedagogical approaches for teachers.



Further evidence suggests that empowering teachers with high-quality instructional materials and lesson plans via structured pedagogy programs delivered remotely can improve learning outcomes.



That said, not all instances of reallocating resources in response to technological changes in education yield positive outcomes. For example,

a study in Costa Rican high schools targeting the seventh-grade math curriculum tested a new instructional approach to promote active learning in geometry (Berlinski & Busso, 2017). This study also evaluated the use of various technologies, including interactive whiteboards, computer labs and individual student computers across different experimental groups. The findings revealed that none of the treatment groups experienced positive effects on learning; in fact, interventions that promoted active learning and integrated technology showed significant negative effects. Despite high levels of teacher engagement and proper implementation, the introduction of technology hindered teacher-student interactions. Similarly, a study in India that provided teachers with continuous training, materials and encouragement to blend their instruction with high-quality videos resulted in negative effects on mathematics scores, null effects on science scores, and adverse effects on instructional quality, teaching practices, and student attitudes toward mathematics and science. In both the Costa Rican and the Indian studies, challenges such as the time spent setting up and transitioning to technological platforms negatively impacted learning outcomes, classroom discipline, and teachers' instructional practices. These findings serve as a cautionary tale, warning against abrupt instructional and curricular changes, especially when they involve significant technological adjustments in the classroom.

In sum, technology has the potential to transform classroom instruction by helping teachers deliver better lessons in pedagogically sound ways, while enabling students to work with materials and resources that are tailored to their specific levels. The most successful interventions in this area do not aim at replacing teachers; rather, they seek to enhance interactions between teachers and students by either freeing up more time for teachers or supporting their instruction. However, not all instances of reallocating resources have been successful. The key to achieving positive outcomes lies in ensuring that the intervention effectively unlocks the desired results. For example, if an intervention aims at supporting teachers' lesson planning, the time teachers spend on that must be reduced. Furthermore, it is essential that the new allocation of resources improves student experiences and learning outcomes. This begs the question: are teachers dedicating more time to student-facing activities because of the introduction of technology in the classroom?

The mere provision of devices does not lead to better learning outcomes

One common intervention in the space of technology in education has focused on providing hardware to students, particularly those who were previously digitally excluded. High-profile examples include the "One Laptop Per Child (OLPC) program, which aimed at equipping every student with a laptop. Governments, NGOs and donors invested heavily in this initiative, striving for a one-to-one device-to-student ratio either by distributing laptops directly or providing classroom sets that were large enough to cover all students.

Even in lower-income countries, increasing access to technology in schools became a significant policy priority or interest (Kozma & Surya Vota, 2014). It is important to recognize that many of these programs were primarily designed to bridge the digital divide and promote equitable access to technology, an objective that was met to varying degrees (Díaz et al., 2022). However, evidence suggests that the goal of improving learning was largely unmet.

Box 3. The challenge of inequality in access to technology

One significant risk of technology-driven education is the potential to exacerbate existing educational disparities if technology access is not universal. When higher-achieving or wealthier students have access to technological tools that their less advantaged peers lack, educational performance gaps can widen. This risk is especially concerning in regions with severe economic inequality, such as Latin America and the Caribbean. For instance, nearly 40% of 15-year-olds from disadvantaged backgrounds in the region still lack Internet access at school, and 20% do not have access to any computers allocated for student use at school. In contrast, access to both resources is universal among disadvantaged students in OECD countries (Arias Ortiz et al., 2024a). Additionally, 94% of students in the richest quintile in Latin America have access to a computer at home for schoolwork, over three times the proportion of those in the poorest quintile (Arias Ortiz et al., 2020a). These gaps affect not only education systems' ability to implement interventions for improving learning outcomes but also their capacity to respond to crises like COVID-19, where education had to shift to remote modalities—disadvantaging those with limited access to necessary platforms and devices.

Addressing these disparities requires efforts to close the digital divide. However, policymakers must also weigh the high costs of providing and maintaining devices or meaningful educational connectivity on a large scale (Drees-Gross & Zhang, 2021). While expanding access to technology and meaningful educational connectivity³ is an enabling condition for more effective, technology-based, student-centered interventions, it does not by themselves improve learning outcomes directly. Thus, they should also be accompanied by investments in quality content and platforms. In addition, investments in teacher training and skills that ensures that teachers can effectively use these materials and tools is paramount (see Section 3). Finally, the sustainability of such initiatives requires trained personnel to manage network infrastructure and maintain equipment, alongside a robust technical support system for school networks, ensuring that technology remains functional and accessible for learning.

Despite widespread efforts to increase students' access to devices, evidence of their effectiveness on their own to improve learning outcomes remains scant. Simply providing hardware has not been shown to directly enhance academic achievement. Evaluations of OLPC programs in countries such as Colombia, Peru, Uruguay and Costa Rica consistently reveal limited or no impact on student performance (Barrera-Osorio & Linden, 2009; Beuermann et al., 2015; Cristia et al., 2010, 2017; de Melo et al., 2014; Meza-Cordero, 2017). In cases where these policies have been studied for their long-term effects, the findings do not show improvement. For instance, a follow-up study of an OLPC program in Uruguay found no significant effects on educational attainment (Yanguas, 2020). Similarly, a long-term follow-up of Cristia et al.'s 2017 study of

³ Meaningful educational connectivity is defined as meeting two main conditions: 1) one megabits (mbps) per second per student in the largest shift at the school; and 2) signal strength greater than -70 decibel milliwatts (dBm) in all educational areas of the school. This allows that a) all students in the shift can make general use of the Internet simultaneously, such as accessing email, news sites, or performing web searches, for example; b) half of the students in the shift can access the Internet at the same time, and among them, one in three can engage in video activities; and c) a quarter of the students in the shift can simultaneously participate in video activities on the Internet. <https://blogs.iadb.org/educacion/es/mas-alla-del-acceso-como-garantizar-una-conectividad-significativa-para-todas-las-escuelas/>

the One Laptop per Child initiative in Peru found no effects on academic achievement. Furthermore, the study reported negative effects on timely completion of primary and secondary education (Cueto et al., 2024.) Additionally, initiatives like replacing textbooks with laptops in Honduras showed no improvement in learning outcomes despite the higher costs involved (Bando et al., 2017). A recurring issue across these initiatives has been the underutilization of devices and insufficient teacher training on how to integrate technology into everyday instruction (Lavinás & Veiga, 2013; Barrera-Osorio & Linden, 2009). Moreover, while students spent more time using computers, as in the OLPC evaluations (Meza-Cordero, 2017), this often came at the cost of other activities, such as homework or outdoor play. In some cases, the provision of technology even had negative impacts on academic outcomes (Angrist & Lavy, 2002; Malamud & Pop-Eleches, 2011).

Overall, evidence linking the provision of technology to higher learning outcomes remains limited. Many of the effective and cost-efficient interventions mentioned in this report depend on hardware and meaningful educational connectivity being available in schools. Although access to devices and connectivity is a necessary condition, it is not sufficient on its own to support learning gains. Technology-based education programs must be rooted in clear pedagogical frameworks (see Box 3). At the same time, experiences from initiatives like Uruguay's Plan Ceibal demonstrate that while merely providing devices does not ensure higher learning outcomes directly (de Melo et al., 2014; Yanguas, 2020), it can help bridge digital disparities. By providing access to personal computers and leading to a greater uptake of Internet services, the initiative narrowed the digital access gap across socioeconomic groups (Díaz et al., 2022). Furthermore, such programs can enhance students' familiarity with digital skills (Rodríguez-Segura, 2022), potentially leading to future labor market benefits.

In this sense, while expanding access to technology should not be viewed as a direct means of improving learning outcomes, it is essential for developing students' skills for learning and success in future digital work environments. Moreover, access to technology can be beneficial for students in the context of future learning interventions, especially disadvantaged students who might otherwise lack access to the technological support their peers have.

B. Expanding access and achieving complete learning trajectories

Remote instruction and training

Digital transformation efforts in education have expanded opportunities for stakeholders such as teachers, administrators, students and parents to access educational resources and get more deeply involved with the educational process. This can both enhance access for those completely outside the education system—thereby increasing the overall coverage of education systems—and encourage greater participation and involvement among those who are marginally included within systems but at risk of disengaging. This section highlights several examples of how technology has effectively supported education systems on both fronts.

Firstly, broad interventions aimed at improving infrastructure can significantly increase access to education, particularly in remote areas where other solutions may be lacking. These areas can suffer from a shortage of teachers in certain subjects, or be places where traditional approaches are financially unfeasible, as

in the case of hard-to-staff schools in isolated environments (see Box 4). For instance, studies in Peru on Internet provision to schools (Lakdawala et al., 2023) and in Tanzania on electrification and instructional tools (Seo, 2017) demonstrate that initiatives to improve digital infrastructure can help deprived regions overcome technological gaps, thereby supporting students and reducing inequalities. In these remote areas where establishing formal schools may be logistically challenging, programs like Mexico's telesecundarias offer viable alternatives for achieving universal enrollment (Fabregas and Navarro-Sola, 2024; Borghesan and Vasey, 2024). Though asynchronous technological interventions of this kind can create a foundational infrastructure upon which more pedagogically aligned initiatives can be developed. In turn, these initiatives can directly improve learning outcomes.

Box 4. The challenge of the “last mile” in school attendance

As previously mentioned, there has been a significant increase in school enrollment rates throughout Latin America and the Caribbean in recent years. For instance, net enrollment in secondary education in LAC rose from 59% in 1986 to 78% in 2018 (World Bank, 2024e). However, the goal of achieving universal enrollment remains a challenge even in primary school, as substantial gaps in enrollment persist both within and among countries. For example, while the regional average of out-of-school children of primary age has fallen to 3.1% (World Bank, 2024c), countries like Honduras and El Salvador continue to report rates of around 18-19%. Moreover, geographical and socioeconomic disparities within countries exacerbate the challenge of achieving universal enrollment. In Honduras, for example, the enrollment disparity between rural and urban children aged 6-11 is 6 percentage points; this rate increases fourfold for those aged 15-17 (CIMA, 2024). Similar socioeconomic differences are evident, with attendance rates for 15-17-year-olds showing a gap of 27-37 percentage points between the highest and lowest income quintiles in Paraguay and Uruguay (CIMA, 2024).

Enrollment decisions within these populations are likely influenced by multiple factors, but a major barrier in the region is the uneven distribution of educational resources, especially in rural areas. This issue is particularly pressing given that around one-fifth of the region's population lives in rural settings (World Bank, 2024d). For example, about 5% of the population in Guatemala and 12% of the population in Peru reside more than 3 kilometers away from a public primary school (Rodriguez-Segura & Kim, 2021). The construction and staffing of schools in these less densely populated areas present significant challenges, as such schools typically incur higher per-pupil costs while yielding low marginal returns on overall enrollment rates.

At its core, the “last mile” challenge of enrolling, retaining and providing a high-quality education for children who are currently out of school or reside in more remote areas is particularly acute among marginalized communities. Digital transformation presents a potential opportunity to provide high-quality education to some of the hardest-to-reach students. By utilizing technology to connect geographically isolated populations at scale and with relatively low marginal costs, enrolment and retention can be increased.

Beyond investment in meaningful educational connectivity and devices, technology programs have facilitated synchronous remote teaching in previously underserved areas. For example, the Centro de Mídias in the Brazilian Amazon delivers synchronous secondary education to remote locations. As such, this program overcomes geographical barriers by providing essential access to secondary education where it might otherwise lack (Cossi Fernandes et al., 2024).

Similarly, Uruguay's Ceibal en Inglés⁴ (CEI) program connects students with foreign English teachers through video conferencing. As such, students are able to access to English language instruction that would otherwise be unavailable due to a shortage of qualified teachers. The program has significantly expanded the reach of English teaching in Uruguay. In 2013, only 27% of primary students received in-person English instruction; with the addition of CEI, nearly all students in Uruguay receive English instruction either in-person or via video conferencing (Kaplan and Reyes, 2022). Moreover, national assessments of English proficiency reveal no significant differences in the outcomes of students participating in in-person English classes and the Ceibal en Inglés program (Marconi et al., 2023). Using the same delivery strategy, CEI has implemented computational thinking (CT) instruction for students in 4th to 6th grade of primary education since 2017. The program reached 83% of urban schools in 2023. The weekly lesson consists of a 45-minute videoconference session led by a remote instructor and assisted by the classroom teacher. Performance data in CT assessments show a reduction in the educational gap between socioeconomic levels, with the difference narrowing from 1.20 points to 0.62, though the results still favor students from higher sociocultural backgrounds (Urruticoechea et al., 2022).

Similarly, a large-scale program in China improved academic achievement and labor market outcomes by offering students in rural schools pre-recorded lectures by effective urban teachers via satellite Internet (Bianchi et al., 2022). Finally, various adaptations of Sesame Street for different contexts have also demonstrated positive effects on early numeracy and literacy skills in young children (Borzekowski and Henry, 2011; Borzekowski, 2018; Borzekowski et al., 2019a; Borzekowski et al., 2019b). These examples illustrate the potential of technology to provide access to high-quality educational content and teaching materials at scale.

Remote instruction does not need to be the sole educational support for students; it can be integrated into traditional educational settings to address challenges such as the shortage of highly qualified teachers in remote areas. For instance, Centro de Mídias, CEI and Mexico's telesecundarias program combine either synchronous or asynchronous lessons with in-person support, where local teachers have access to reference texts and instructional guides aligned with the lectures (Borghesan and Vasey, 2024). This holistic approach helps fill in gaps in staffing and content knowledge. In turn, this augments access to quality education without the immediate need to substantially increase the number of highly qualified teachers, which could otherwise lead to recruitment and retention challenges.

In contexts where qualified teachers for specific subjects are scarce or where it is not feasible to have fully staffed schools, live broadcasting of lessons or direct instruction via technological platforms can be an effective alternative. Apart from Centro de Mídias and CEI, case studies from Ghana and India have shown the potential of remote live instruction to improve learning outcomes. Both of these case studies report significant gains in at least one subject through live lessons delivered by centrally located teachers (Johnston and Ksoll, 2022; Naik et al., 2020). Similarly, live tutoring through phone calls has proven to be a promising method for delivering remote education during emergencies and school closures across five countries in Asia and Sub-Saharan Africa (Angrist et al., 2023a).

The cost-effectiveness of remote teaching, whether asynchronous or synchronous, is particularly promising because the primary costs are fixed, resulting in low marginal costs per additional student. For example,

⁴ CEI is an English synchronous language instruction program designed for primary-school grades 4 through 6, with remote English-speaking teachers who give weekly lessons to groups of students through a videoconferencing link-like those used in workplaces for remote meetings. These English classes are conducted jointly with the classroom teacher who prepares and facilitates the class. CEI was launched in 2012 as a way to universalize English language instruction coverage.

an Indian program that reached nearly 2,000 schools achieved strong learning gains at a per-pupil cost of less than USD 2 per year (Naik et al., 2020). Therefore, when there is access to adequate devices and meaningful educational connectivity, technology can distribute instruction with high-quality content at scale—keeping marginal costs minimal as most of the costs are around the development of the material, not the distribution of it. Even when infrastructure like meaningful educational connectivity needs to be provided, technology may still offer more cost-effective and sustainable alternatives to fully staffing schools in sparsely populated areas—an issue that, while ideal, might present other challenges in the medium term around teacher retention.

In addition to delivering either synchronous or asynchronous instruction remotely, technology can also help stakeholders, such as teachers, access content and tools that would otherwise be unavailable to them. For example, remote teacher training through virtual coaching and meetings has shown potential in studies conducted in South Africa (Kotze et al., 2019; Cilliers et al., 2022) and Ghana (Wolf et al., 2018). These studies suggest that virtual teacher training can provide benefits comparable to on-site training, while being more cost-effective and logistically easier to scale. That said, a longer-term follow-up in the South Africa study indicated some diminishing returns from virtual coaching. While additional research is needed to better understand the effectiveness of this form of professional development, the potential for technology to bring tools and instruction closer to underserved students and unaccompanied teachers remains promising.

More student attendance and parental involvement

In addition to enabling underserved students and unaccompanied teachers to access the education system and opportunities available to their peers, technology can also engage other stakeholders, such as students and parents already within the system, in more active participation. There is growing evidence supporting cost-effective initiatives that disseminate information at scale to encourage positive behavioral changes.

Box 5. The challenge of information asymmetries in decision making

Inaccurate information about student performance or behavior can lead parents and policymakers to make misguided decisions about allocating time and resources. Furthermore, substantial evidence shows that parents and policymakers often hold mistaken beliefs about students' actual performance levels. For example, a study in Chile found that many parents lack accurate information about their children's academic performance. 26 percent of parents were unable to report their child's grades correctly, and 48 percent could not approximate their child's school attendance over the previous two weeks (Berlinski et al., 2022). In Malawi, a study found that parents' beliefs about their children's academic performance differed from actual performance by over one standard deviation on average. In that study, only two-thirds of parents correctly identified which of their children performed better academically (Dizon-Ross, 2019). Similarly, in Colombia, parents underestimated their children's reading abilities by an average of half a standard deviation, while overestimating their math abilities by nearly a full standard deviation (Barrera-Osorio et al., 2020). Finally, a study of a low-income community in Los Angeles in the United States found that parents overestimated the extent to which their children completed assignments on time, displaying a consistent bias toward viewing school effort favorably (Bergman, 2021). In turn, some of these same studies suggest that correcting parental beliefs can yield changes in their behavior and/or in their children's performance. In the Malawi study, informing parents about their children's actual performance led them to adjust investments in each child's education accordingly.

Likewise, in the United States, aligning parents' perceptions about their children's homework completion with reality resulted in moderate gains in academic performance, especially in mathematics.

The issue of misaligned beliefs about children's academic performance also extends to policymakers. A survey across 35 countries revealed that, while policymakers generally held accurate perceptions of schooling levels, educational spending and economic returns, they significantly overestimated literacy levels in their education systems. More specifically, they estimated that, on average, about half of 10-year-olds in their country could read, whereas actual assessments showed figures closer to one in five students (Crawford et al., 2021).

Inaccurate perceptions of student performance can lead to well-intentioned but potentially ineffective policies and parental decisions. Where accurate information can correct these beliefs and stakeholders have the tools to act effectively, bridging these informational gaps presents a promising strategy for improving educational outcomes.

The information shared with parents and students through these programs can take various forms, such as real-time data on student performance, tips on how to better support students or insights into aspects like the returns to education or school quality that may not be readily available to parents (see Box 5). For instance, a program in Chile used high-frequency text messaging campaigns to inform parents about their children's performance, attendance and behavior (Berlinski et al., 2022). This intervention led to significant improvements in test scores and attendance within just four months.

Remote support programs have also shown promise in encouraging stronger practices at home. In Uruguay, a behavioral intervention that sent messages to parents of preschool children via a mobile app for 13 weeks resulted in stronger developmental outcomes for these children, particularly those in more remote areas. The intervention also improved school attendance for certain student groups (Mateo Díaz et al., 2020). Similarly, an intervention in Goiás, Brazil, which sent behavioral nudges via text messages to students or their caregivers over 12 months during school closures, targeted socio-emotional skills during remote learning and helped prevent 7.5% of learning losses in math and 24% in Portuguese (Lichand et al., 2024).

Another area of information asymmetry that can influence parental behavior is parental perception of the value of education. As such, providing information about the returns to education has been effective in shaping parental behavior. For example, in Haiti, a non-technology-based intervention that provided information on school quality led to improvements in student achievement at scale (Borger et al., 2024). Technology-based studies aiming to correct misconceptions about the returns to education using context-sensitive videos and infographics have also positively impacted student performance and aspirations (Neilson et al., 2014, 2018). While the study in Haiti shows that technology is not always necessary for such interventions, when there is capacity, technology can enable policymakers to reach a larger share of the population at a fraction of the cost of traditional methods. In this way, technology can increase the cost-effectiveness of these programs.

Technology has also been employed in LAC to distribute information about school selection. A multi-country study in Ecuador and Peru provided personalized information on schooling alternatives and placement risks to parents via email and WhatsApp. The study showed that this information influenced parental preferences and school choices in Peru (Arteaga et al., 2022). In Ecuador, the intervention led to no significant changes in behavior. The authors suggest several possible reasons for these results, including

differences in information distribution channels and a lower density of schools in Ecuador, which might have meant that parents already had sufficient knowledge about their local educational options.

Similarly, technology-enabled behavioral interventions can be tailored to teachers, allowing policymakers to implement these programs on a large scale. For example, a study on the effects of providing information to assist teachers in making better assignment decisions within Ecuador's centralized teacher assignment system (Elacqua et al., 2022) found that teachers were much more likely to change their preferences and add new schools to their applications. This ultimately resulted in a new stable distribution of teachers after assignments were completed. Additionally, interventions in Peru engaged teachers and school officers through SMS reminders about deadlines. Furthermore, these interventions incorporated behavioral insights like personalizing messages with recipients' names (Dustan et al., 2023; Vakis and Farfan, 2018).

Although these informational campaigns generally produce modest effects, their low cost and scalability still make them appealing. Once a system for automating message delivery via platforms like WhatsApp or SMS is in place, the marginal cost of adding new users or sending additional messages is relatively minimal. Therefore, the low costs may justify the smaller average effects on ultimate outcomes like learning outcomes.

Despite the potential benefits of using technology to scale behavioral interventions in a cost-effective manner, there may be limitations to how effectively technology can expand these interventions for parents or teachers. For instance, a study in Chile sought to address the shortage of qualified teachers by encouraging high school seniors to pursue education degrees (Ajzenman et al., 2023). The study delivered information via WhatsApp about the higher education application process, accompanied by behavioral insights emphasizing different motivations for choosing this career. The study compared two methods of delivering the messages: one through human agents and the other via a chatbot. Although both interventions were designed to deliver similar content, the human-delivered approach was highly successful. The study found that, if scaled up, these human-delivered messages could reduce the projected teacher deficit in Chile by 0.8 to 2 percent by 2025. In contrast, the chatbot intervention showed much smaller effects—between two-thirds and one-half less. As such, these effects were generally insignificant. The study offers a cautionary tale—although technology might be effective for this type of intervention as a delivery platform, human-produced content seems to be more efficient than tech-generated output.

Overall, well-designed and properly implemented technology-based solutions can significantly enhance stakeholder participation in education systems, both in terms of coverage and active engagement. By facilitating access to instruction where it was previously unavailable and influencing the behaviors of educational stakeholders in scalable and cost-effective ways, technology can play a crucial role in expanding the reach and impact of education systems. However, contextual adaptation and a clear focus on addressing specific constraints within each system are essential to ensure these interventions foster greater engagement and effectiveness.

C. Efficiency in service delivery

In education, as in other fields, technology can help organizations and governments become more efficient—not just effective—in delivering services. Technology can do so by: 1) enhancing the quality and reach of service delivery and monitoring; 2) reducing costs; and 3) increasing output (e.g., contact hours with students) without significantly raising expenses. Often, these interventions can overlap with other goals,

like raising learning outcomes. In the process of doing so, these interventions can increase the return on investment of governments in education through a better utilization of resources. In this section, we will explore some of the ways in which technology has enabled this type of reform.

Better quality of learning data

Learning assessments are a crucial element in education systems, encompassing everything from large-scale monitoring and high-stakes assessments to formative, teacher-led assessments aimed at adjusting classroom instruction. Often, the data generated from these assessments can inform decision-making to better understand the effectiveness of specific policies or the overall trajectory of education systems (see Box 6). However, generating high-quality data on a large scale often presents a challenging trade-off between cost and quality. For example, the more decentralized the data collection process (e.g., teacher-led assessments), the lower the cost, but also the more compromised the data integrity tends to be. Conversely, centralized data collection is more costly to administer but typically yields more reliable results and improved governance.

Box 6. The challenge of generating accurate learning data on a large scale

High-quality data on learning outcomes is essential for effective, evidence-based policymaking in education. Understanding how learning outcomes change over time allows policymakers to gauge the long-term trajectories of the educational system and ensure that learning outcomes remain central to policy development and implementation. Access to robust data on student performance in Latin America remains limited, despite recent positive trends. For example, since 1995, 14 countries in the region have participated in at least one of the 19 assessment rounds conducted by the International Association for the Evaluation of Educational Achievement (IEA) across four different assessments (Arias Ortiz et al., 2024). However, participation by Latin American and Caribbean countries in these four assessments has been consistently low and has declined even further in recent rounds. However, on average, countries have only participated three times, and the most recent participation was, on average, in 2015. Similarly, while participation in international and regional assessments like ERCE and PISA has been increasing, these assessments are not conducted at the census level, and there are significant intervals between administrations. For example, ERCE has been administered every 6-7 years since 2006, which limits its potential use for more agile decision-making. Even at the national level, assessments remain sparse: since 2021, 7 out of 18 studied countries in the region had no recent national-level data on primary school learning outcomes (Arias Ortiz et al., 2024).

While large-scale data collection can present downstream challenges—such as the risk of distorting instructional practices to "teach to the test" or over-assessing children—the most fundamental, upstream issue is ensuring the accuracy and integrity of the data. When assessments are administered on a large scale, often by parties who may have a vested interest in showing higher performance, such as the students' own teachers, there is a risk of data manipulation. Issues with data quality are common and have been documented across a range of countries, including Mexico (Martinelli et al., 2018; Cáceres et al., 2021), Indonesia (Berkhout et al., 2024), India (Singh, 2024), and Italy (Lucifora & Tonello, 2020). Without confidence that the data are accurate and reliable, their use for policy decision-making becomes questionable. Therefore, as efforts continue to expand the collection of data on learning outcomes at national, regional and global levels, it is equally important to ensure that the data are both reliable and accurate.

Technology has been employed to enhance the quality of data on learning outcomes. In India, a study found that scores from paper-based assessments administered by teachers were 16-20 percentage points higher than scores from the same students when re-tested by independent monitors (Singh, 2024). This distortion was significantly reduced when classrooms were assessed via tablet-based tests, with only 2-5% of classrooms showing indications of cheating. Technology has made cheating on certain kinds of assessments more difficult, as design features like displaying one question at a time limit opportunities for copying answers or receiving help from teachers. In a different study in Indonesia, a large-scale assessment that switched from paper-based to computer-based testing saw test scores drop by nearly half a standard deviation (Berkhout et al., 2024). The authors interpret this decrease in test scores as an indication that computer-based testing reduced cheating, as the software generated thousands of test versions, preventing students in the same room from having identical questions. Importantly, this study also observed an increase in test score variation within schools, suggesting that the technology-enhanced data quality improved the ability to distinguish high- and low-performing students, making the assessment a more accurate reflection of actual proficiency levels.

● Reducing costs of learning-centric programs

Another way technology can enhance efficiency and reduce costs is by providing after-school tutoring experiences like those discussed in a previous section, with a reduced need for human involvement in this process. A study in South Africa evaluated an after-school computer-assisted program that targeted each student's specific weaknesses in math, allowing them to choose the topics they wanted to work on (Böhmer et al., 2014). This program effectively improved foundational math skills, addressing content gaps that regular instruction might have overlooked, as such foundational knowledge was often assumed for the grade level. A comparable personalized-learning, after-school program in India also led to significant improvements in learning outcomes.

It is important to compare the cost-effectiveness of technology-driven after-school programs and those led by human tutors. In South African study, technology complemented classroom instruction by offering after-school support at a fraction of the cost of a human-led program. Even human-led tutoring programs delivered remotely, especially during emergencies or school closures, have shown significant effectiveness in some cases (though not all), without the added cost of transportation for tutors. In this sense, technology has enabled a more efficient use of existing resources, such as hardware in schools, while also lowering the costs of tutoring programs, all while improving learning outcomes.

● Stronger, at-scale monitoring

Technology has been used to monitor teacher absenteeism more effectively in low- and middle-income countries. This is important, because teacher absenteeism reduces overall instructional time, increases the per-hour cost of teacher salaries and likely leads to lower learning outcomes (see Box 7). Moreover, more equitable and standardized enforcement of teacher attendance policies provides a fairer approach for most teachers who fulfill their responsibilities. Yet, in-person monitoring of teacher attendance or time-on-task via analog methods presents significant challenges. It is often prohibitively expensive due to the need for extensive human resources and travel. Even when feasible, such approaches are vulnerable to issues like collusion between supervisors and school staff or "observer effects," where teacher behavior changes on days when visits occur. In this context, technology-enabled verification offers a scalable alternative that does not require a massive expansion of supervisory staff, and that is harder to manipulate compared to sporadic human inspections.

One technology-enabled approach to standardize and homogenize verification of teacher attendance on a large scale involves biometric-based verification. For instance, the challenge of teacher absenteeism has been addressed in countries such as Indonesia, India and Haiti (Gaduh et al., 2022; Duflo et al., 2012; World Bank, 2015) using timestamped cameras to capture photographs of teachers with their students as proof of attendance. These interventions linked a portion of teachers' salaries to verified attendance and resulted in notable improvements in student test scores in Indonesia and India. However, their success hinges on effective implementation and uptake, as evidenced by Haiti, where low participation rates and logistical challenges undermined the initiative. This underscores the importance of designing and executing these interventions carefully to ensure they achieve their intended impact.

Box 7. The challenge of inefficient uses of teachers' time

Teachers are essential to the functioning of education systems, and as such, substantial portions of global education budgets go toward their compensation. For instance, LAC countries where data are available invest approximately three-quarters of their total public education expenditure on staff compensation (UNESCO Institute for Statistics, 2024). Given that teachers play a crucial role in shaping student learning outcomes (Chetty et al., 2014), improving the efficiency of this investment is essential for optimizing overall public spending in education.

Evidence suggests that in Latin America and the Caribbean, there is room to enhance the efficiency of how teacher time is allocated. First, teacher absenteeism remains a concern, directly impacting instructional time. For example, a regional study shows that in some education systems in the region, teachers are absent from the classroom for 6-11 percent of total instructional time. In addition, this same study found that when teachers are in the classroom, 9 percent of teaching hours are lost to “off-task” activities (Bruns & Luque, 2015). To put this into perspective, losing 10 percent of instructional time is equivalent to about 20 school days in a 200-day academic year (Bruns & Luque, 2015). Beyond the detrimental effects on learning outcomes, the fiscal implications of teacher absenteeism are substantial, with costs reaching \$1.5 billion annually in India (Muralidharan et al., 2017) and comprising up to 11 percent of the primary education budget in Tanzania (Schipper & Rodriguez-Segura, 2022).

Even when teachers are present in schools, inefficiencies in their assigned time allocations and responsibilities persist. The same report by Bruns and Luque (2015) found that the average teacher in LAC may lose up to one day of instructional time per week due to inadequate preparation or administrative tasks, such as taking attendance or distributing materials. Thus, even when teachers are available, their responsibilities often divert them to tasks that do not directly contribute to improved learning outcomes.

Technology-based interventions can enable teachers to focus more on student-centered, learning-driven activities by reducing time spent on administrative tasks and maximizing in-person, on-task time. By addressing these inefficiencies, technology can help increase instructional time, leading to better learning outcomes and a more effective return on public investment in education.

The broader lesson from these initiatives aimed at lowering teacher absenteeism is not necessarily about the specific, camera-based technology used—which might raise concerns about the ethics of their usage in classroom. Rather, the lesson is that technology can enable large-scale monitoring that would have been impossible or prohibitively costly before. Importantly, by combining technology-enabled monitoring with well-designed incentives, program designers in India and Indonesia were able to achieve the goal

of modifying teacher behavior on a large scale. That said, in both contexts, the technology did not act in isolation. Monitoring alone, without the right incentives in place for the “right” behavior, might not have been as effective. This highlights the importance of integrating technology-based interventions holistically within education systems to bring about real gains in efficiency.

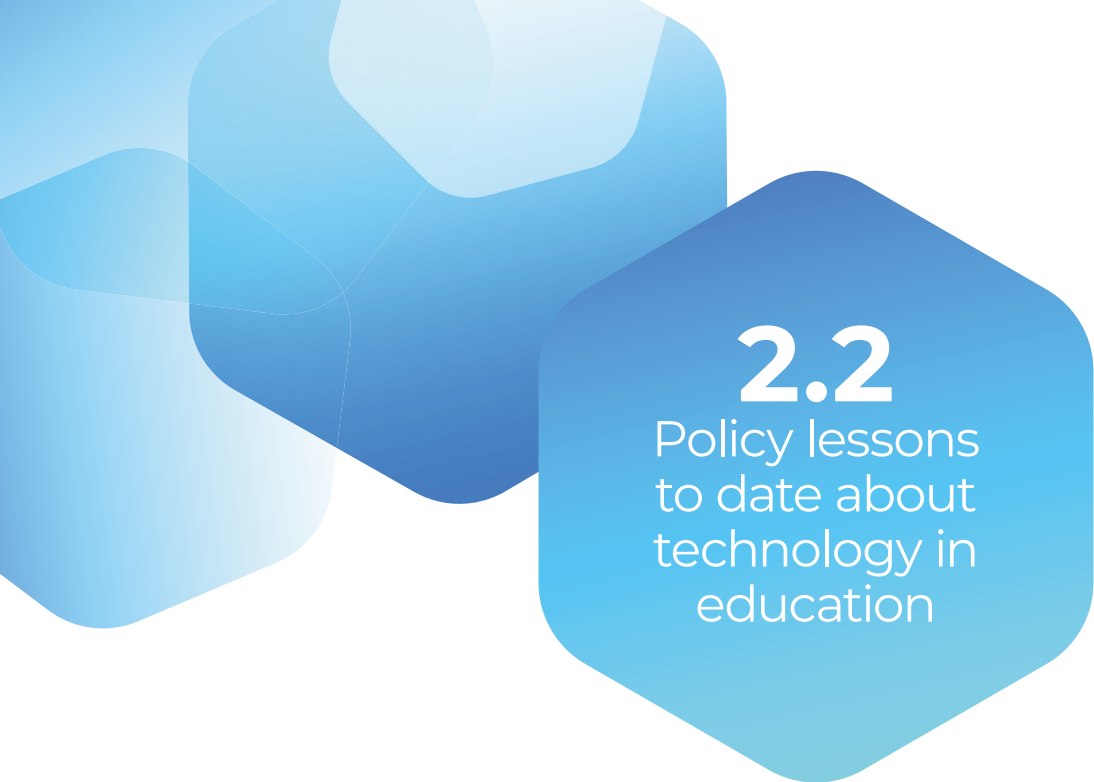
● Reallocating resources towards more effective uses

At its core, education is a human endeavor that requires active and effective instruction, attention and personalization by teachers to engage every student. Ideally, most of a teacher’s workday would be devoted to student-centered activities that require in-person, human involvement. That said, teachers are often overburdened by time-consuming operational and administrative tasks, which in turn likely the time available for student interaction.

“**At its core, education is a human endeavor that requires active and effective instruction, attention and personalization by teachers to engage every student.**”

Structured pedagogical interventions, such as those digitally distributed in Senegal and Kenya, can help alleviate some of these burdens. By reducing the time teachers spend on tasks like lesson planning, these interventions free up more time that could be used for more instruction and individualized attention. As such teachers can adapt resources like lesson plans to their individual teaching contexts. While these interventions do not necessarily need to be delivered digitally, the use of technology —where adequate hardware and meaningful educational connectivity allow— can make the distribution of lessons at-scale more seamless, equitable and can facilitate more frequent revisions to course content. Therefore, while not essential, technology can enhance the effectiveness and scalability of such interventions.

Policymakers must be mindful that even if structured interventions succeed in reducing teachers' workload, it is crucial that the time freed up is actually used to benefit students. To achieve this, the reallocation of time must be clearly communicated, incentivized and monitored. Without proper oversight, there is a risk that the free time could be diverted to activities that do not lead to improvements in the educational instruction. More broadly, this example of digitally supported structured pedagogy illustrates how technology-based interventions can shift resource allocation, such as teacher time, toward more effective arrangements. When combined with other system-wide inputs like monitoring and incentives, these interventions can generate a higher return on existing resources, such as teacher time and salaries.



2.2

Policy lessons to date about technology in education

Over the past several decades, an abundance of evidence has accumulated regarding the effects of technology on education. This has led to broader discussions about how various technologies—whether artificial intelligence or other forms— can be integrated into education systems to enhance their effectiveness and efficiency. Below, we outline six key policy lessons derived from the emerging evidence on technology in education (see summary Table 1), which can guide future reforms:

● Technology is not always the most effective approach

Technology, like any other tool, has its own comparative advantages and disadvantages. Technology can empower teachers by enhancing their instructional practices and enabling them to reach, via videoconference or other technologies, students in multiple locations simultaneously. At the same time, certain tasks, particularly those requiring human expertise and interaction, tend not to be well-suited to technological interventions. Even when technology-based approaches may deliver similar learning outcomes to non-technology-based ones, they might do so at a higher cost, reducing the overall cost-effectiveness of education investments (Bando et al., 2017). Policymakers should carefully consider whether technology offers unique advantages in terms of effectiveness or cost before implementing a technology-based intervention.

● Design to the educational challenge

Even if technology appears to address a specific challenge, policymakers must develop a clear, evidence-based theory that explains how the technology will tackle the problem in the specific education system. Without this mapping, they may discover that the "challenge" they aimed to solve was not a pressing constraint, or that stakeholder incentives are misaligned with the effective use of the intervention. Well-intentioned and costly interventions have sometimes produced negative results due to the absence of a clear theory of change, and the absence or weakness of necessary enabling conditions (see IV.2)

● Technology in education excels at customization, educational management and remote engagement

The most promising technology-based interventions are promising because of the comparative advantage they offer in specific situations. For example, evidence shows that technology can create extensive tailored or adaptive materials, such as practice problems for math, facilitate mass reach, as seen in remote tutoring programs, and enable stronger governance by improving teacher assignments at scale. These three capabilities represent areas where technology is expanding. Furthermore, these capabilities are likely to be enhanced by AI-based solutions, as described in the next section. This will likely increase technology's advantage over non-technology-based interventions in these areas of education, further improving outcomes.

● Holistic use of technology

While technologies that directly engage students tend to generate the most excitement, less visible applications can also yield significant benefits. For example, reminders can help parents stay informed about their children's education, and digitally distributed, adaptable lesson plans can reduce teacher fatigue and free up time for direct student interaction. Such behavioral interventions can effectively address issues such as gaps in information, accountability and duty enforcement, while also being scalable and cost-effective. Even when access to technology does not immediately affect learning outcomes, it serves as a necessary foundation for implementing other educational solutions, especially in remote or disadvantaged areas. A balanced approach that considers various intervention types is essential for addressing educational deficiencies.

● Implementation fidelity and stakeholder engagement drive the success of digital transformation

The success of an intervention hinges on both the quality of its implementation and the active participation of the stakeholders that are critical to its success. Interventions that enhance stakeholders' efficiency or empower them to achieve better outcomes are more likely to be adopted and utilized at a sufficient level to improve educational results. Similarly, the quality of implementation significantly influences both uptake and overall effectiveness; even well-designed projects can fail if poorly executed.

● Technologies can widen inequalities

Depending on the resources required to implement a program, technology-based interventions can exacerbate disparities among disadvantaged populations. For example, in Paraguay, 85% of students attending schools in the highest socioeconomic quintile have access to computers at school, while less than 56% of students in the lowest quintile do. Similarly, in Guatemala, 91% of students attending schools in the highest socioeconomic quintile have access to computers at school, while less 65% of students in the lowest quintile do (Arias Ortiz et al., 2024a). These dynamics highlight the importance of addressing inequality through policy choices. Countries must consider not only where to implement programs but also the urgency of addressing inequalities to ensure that large-scale technological interventions do not further disadvantage already marginalized communities.

Table 1. Summary of existing evidence and documented uses of technology in education to advance policy goals related to learning, access and efficiency

POLICY GOAL	CHALLENGES DIGITAL TRANSFORMATION CAN ALLEVIATE	EXAMPLES OF EVIDENCE-BASED USES	AVAILABILITY OF EVIDENCE AND GAPS	POTENTIAL PITFALLS AND CHALLENGES
 MAXIMIZING LEARNING IN THE CLASSROOM	Wide range of proficiency levels within a single class. Gaps in teachers' content knowledge and pedagogical skills. Limited time during the school day for student practice.	Independent student practice and reinforcement, particularly after school, with customized content tailored to each student's needs. Complementing classroom instruction through the delivery of high-quality media content, either synchronously or asynchronously. Provision of teacher lesson plans and other instructional materials at scale, facilitated by technology.	There is strong evidence that technology-enabled practice and instruction can lead to medium-to-large gains in learning. Further understanding is needed around optimal levels of dosage, customization and user experience. Evidence on the use of technology to complement teacher instruction and support pedagogical practices shows promising medium-to-strong gains in learning. However, more research is required on how the availability of technology and teacher familiarity with it may moderate these effects.	Inequities in access to technological infrastructure, such as devices and meaningful educational connectivity, may exacerbate existing gaps. Platforms need to be refined and adapted to the local context and education system. Teachers must be comfortable with technology and properly trained to ensure its seamless integration into the classroom.
 EXPANDED ACCESS AND COMPLETE TRAJECTORIES	Insufficient access to high-quality education in remote or sparsely populated areas. Student disengagement and dropout. Information asymmetries among policymakers, teachers, parents and students.	Distance instruction, whether synchronous or asynchronous. Scalable, low-touch delivery of information to parents and teachers on effective practices and student progress.	The existing body of evidence strongly suggests that well-designed and integrated remote instruction can expand access to education for remote populations. In settings with limited teacher capacity, evidence remains limited on the extent to which well-designed remote education can or should replace teacher-led instruction. The literature indicates that teacher attendance monitoring through technology may have positive effects on instructional time and learning; however, further research is needed to address the political risks associated with implementing this type of intervention in public systems.	High upfront, fixed costs for remote education programs with a technological component when infrastructure is lacking. Information alone may not be the primary constraint on enabling more effective behavior.
 EFFICIENCY IN SERVICE DELIVERY	Poor data quality on learning outcomes at scale. Inequitable distribution of teachers and resources at the system level. Inconsistent monitoring of compliance with allocated instructional time.	Technology-enabled testing to collect data with greater integrity and a reduced risk of cheating. Reduced tutoring costs through individualized software or remote phone-based tutoring. Remote, technology-enabled monitoring of teacher attendance. Freeing up teacher time from non-student-centric tasks by providing lesson plans or automating routine activities.	While evidence regarding data collection at scale spans multiple contexts, more case studies are needed to explore how countries in the region can use technology to collect better and more frequent data, particularly in areas with limited connectivity. Certain elements of education systems that could enhance efficiency, such as the establishment or improvement of an education management information system (EMIS), may be challenging to evaluate rigorously for causal impact on the system.	Potential over-reliance on technology-based decision-making without corresponding increases in government or teacher capacity. Risks in data management regarding the protection of student and teacher privacy, particularly concerning sensitive information.

3.

Disruption?
The new opportunities
and challenges
presented by AI



Rapid advancements in artificial intelligence, coupled with the increasing availability of AI-powered tools, have led some to identify what is seen as a new era of disruption in education. While technology has already made significant strides in transforming educational landscapes, the scope and speed of change driven by AI may call for a more nuanced analysis (Box 8).



With capabilities such as mass production of tailored content, automation of data analysis and more accessible multilingual translation, AI is poised to bring transformative shifts in education.



In this section, we explore the potential of AI to address the three key education policy goals presented in section II. This approach allows us to address the distinct opportunities and challenges that AI brings to improving learning, access and efficiency. Analyzing in detail the implications of AI in education today is essential for shaping policies that remain relevant as technology evolves. As this chapter shows, AI not only enhances existing processes but unlocks new possibilities. With capabilities such as mass production of tailored content, automation of data analysis and more accessible multilingual translation, AI is poised to bring transformative shifts in education.

As we explore these opportunities and challenges, it is essential to consider how governments can strategically use AI to enhance education systems at all levels. As highlighted in the previous chapter, the integration of AI should be grounded in the lessons learned from previous experiences with educational technology to avoid the pitfalls encountered in earlier initiatives. It is important to emphasize that our analysis focuses on teaching and learning with artificial intelligence, rather than teaching and learning *about* AI. Teaching and learning with AI involves integrating AI tools to enhance educational processes, such as using AI-driven platforms for personalized learning or administrative tasks. In contrast, teaching and learning about AI focuses on imparting knowledge regarding AI technologies, their development, applications, and ethical considerations. Teaching about AI is extremely important and there is a growing consensus that education systems should include learning about AI in their curricula (World Economic Forum, 2023). There is still a lot of progress to do, given that less than 10% of schools and universities have developed institutional policies and/or formal guidelines regarding generative AI (UNESCO, 2023). We focus on understanding whether and how the deployment of AI in education can enhance human capacities and promote effective human-machine collaboration in learning environments.

Box 8. What is artificial intelligence?

The rise of artificial intelligence (AI) into broad public use and discussion, especially following the launch of tools like ChatGPT in 2022, has led to diverse perspectives on how to define AI and how it differs from previous technologies. While some limit the definition to "generative AI," others adopt a broader view, including tools that have been widely used for years such as automated data analysis and predictive analytics. In this report, we adopt a comprehensive definition to encompass a wide range of potential educational applications, which may differ significantly in use cases, functionalities and associated risks. Following the framework of Salas-Pilco and Yang (2022), we define AI-based applications as including the following:

- machine learning, which consists of algorithms that analyze data to identify patterns and make predictions that enable summary-creation of data;

- deep learning, a more advanced form of data analysis that uses neural networks to process larger and often unstructured data like audio and images;
- natural language processing, which analyzes human text based on grammatical structures and semantic equivalencies to "understand" and generate text.

These technologies can support both generative features, such as creating novel content from training data and performing more routine tasks, such as analyzing data to uncover insights or automate processes. By adopting this wider perspective in this report, we aim to explore the full spectrum of how AI can be used in education, from the personalized generation of materials to data-driven decision-making.

3.1

AI's role in education: potential learning, access and service delivery benefits

A. Maximizing learning in the classroom

Identifying students who need additional support

When resources are limited, not only is customizing instruction challenging, but even the more fundamental task of identifying student needs becomes difficult. In schools with large class sizes or teachers who lack the expertise to identify students who need individualized follow-up, for example, AI has the potential to help. In cases like these, AI could assist both by pinpointing which students require support in specific areas and recommending targeted interventions for those falling behind.

For instance, AI applications have been deployed in Ghana (Henkel et al., 2024) to measure oral reading fluency. Oral reading fluency is a valuable metric for measuring reading proficiency and development, but it is challenging to train teachers on a large scale to collect this information reliably. In addition, it is time-intensive to perform evaluations of entire classrooms in a dependable manner. In the Ghana study, AI tools yielded results that correlated strongly with scores assigned by expert human raters. This demonstrates the potential of these tools to quantify oral reading fluency. If future iterations also incorporate reliable recommendations derived from these outcomes, teachers could act upon them. In all, the Ghanaian study demonstrates that AI has the potential to help teachers beyond the mere automation of administrative tasks, such as attendance tracking or parent-teacher communication management. As such, it may free up teachers' time specifically for instruction.

Improving customization with AI-powered chatbots and tutors

Second, AI chatbots can provide customized practice and short lessons tailored to each student's specific level, while common platforms like WhatsApp can disseminate these lessons both within and outside of the classroom. For example, the in-class use of an AI-powered conversational math tutor on WhatsApp led to significant learning gains in Ghana through weekly 30-minute sessions over eight months (Henkel et al., 2024). This tool can also be used at home. Other tools also use WhatsApp as a medium to reach students. The platform, SiyaTutor, in South Africa also offers this type of AI-driven engagement through WhatsApp—

enabling many students to access lessons at home through a relatively common technology. While the personalized delivery of educational content to students is not new, the fact that common platforms like WhatsApp can disseminate it widely is novel and expands the reach of such interventions.

Box 9. A chatbot mathematics tutor in Ghana

The promise of individualized, human-led tutoring has shown significant potential to close learning gaps (Kraft et al., 2024). However, the feasibility of such interventions can be hindered in contexts with limited education budgets and a shortage of skilled tutors. AI-based tools, with their ability to understand student prompts, adapt content and generate extensive practice materials, offer a promising solution for delivering individualized tutoring on a large scale in systems where traditional approaches are prohibitively expensive or difficult to implement.

In Ghana, “Rori,” an AI-enabled mathematics “tutor” available on WhatsApp allows students to engage with a curriculum of over 500 micro-lessons. Each lesson includes a brief explanation and series of practice questions tied to a specific learning goal. A core feature of Rori is its use of natural language processing, which enables students to interact with the chatbot using conversational language rather than a button-based interface. This allows Rori to better interpret students' responses and questions, while also fostering more open-ended conversations.

A randomized controlled trial evaluated Rori with students in grades 3-8 (Henkel et al., 2024), who participated in two 30-minute sessions per week during their study hall period. While teachers were present to address technical issues, students worked independently with the chatbot. The control group, by contrast, followed the standard curriculum without access to Rori. The study found that Rori led to learning gains of 0.36 standard deviations, a large effect size in absolute terms and over twice the average growth observed over a six-month period among the control group. This case study highlights how AI-powered tools like Rori can enhance access to critical resources, such as individualized instruction, in resource-constrained contexts through existing platforms like WhatsApp, and ultimately improve learning outcomes.

Furthermore, AI-enabled “tutors” or chatbots are promising due to the flexibility and adaptability AI provides in creating real-time, customized responses to student inputs. Chatbots can act on student inputs, and subsequently provide insights that teachers can use to improve their classroom instruction. While different AI-enabled chatbots have varying features, existing products already support not only at-home, independent practice but also teacher-guided individual work integrated into classroom instruction. For instance, the American AI company Flint allows teachers to set parameters for chatbots to address specific learning objectives and assign them to students. These parameters include subjects and themes to ensure curriculum alignment, as well as other features such as the degree of the AI tutor’s involvement and support. The same tool then enables teachers to monitor responses and aggregate insights for the class.

In addition, AI-powered chatbots like Flexbook offer aggregated performance data. A chatbot such as this offers two potential advantages—facilitating independent practice with tailored feedback and support, and enhancing teacher effectiveness through comprehensive analytics. These analytics promise to identify areas where the class is struggling overall and could help teachers identify what skills merit targeted reinforcement in subsequent lessons.

Despite the potential of AI-enabled chatbots to support students directly—especially when one-on-one tutoring is not possible due to a lack of resources, large class sizes or limited teacher capacity—this technology is constrained by the need for adequate device availability and connectivity. Similarly, the potential of AI-enabled chatbots to assist teachers through analytics on class performance depends on device availability and Internet access. Without additional efforts to level the playing field, potential AI-chatbot benefits are likely to favor more advantaged groups. Similarly, existing evidence shows that even well-designed products must be carefully integrated with curricula and teachers’ instructional practices if they are to be efficacious. As such, the use of these chatbots should go hand-in-hand with meaningful teacher training. That way, teachers can learn how to effectively use these tools to complement instruction.

● Revolutionizing instructional design

A third, and perhaps more disruptive potential use of AI is how it could change instructional design at both the lesson and course level. Generative AI has the potential to create and revise lesson plans aligned with best practices, curriculum standards and policy guidelines specific to a given context. The adaptability of generative AI to different requests allows for greater flexibility than previous technologies. Not only can it generate a cohesive set of lessons—assuming it is trained on a suitable corpus—but it can also tailor curriculum recommendations to each teacher’s specific circumstances. For instance, if a school needed to close for a week due to a local emergency, a teacher could use AI to condense lessons, ensuring that key curricular topics are still covered despite the shortened time frame, or that the units skipped are those that are less central to the overall curriculum.

This type of AI-driven support with instructional design is becoming a reality in several contexts. In Brazil, Plu, an intelligent assistant developed by SOMOS Educação and Amazon Web Services, generates detailed lesson plans complete with illustrations, suggested student activities and customized questions. This tool aims to reduce the time educators dedicate to class preparation, thereby allowing them to focus more on personalized student engagement. In Chile, UmmlA is under development as an AI-based lesson planner that enables teachers to design active and student-centered learning experiences, such as project- and challenge-based learning. Finally, in Sierra Leone, the AI-powered TheTeacher.AI chatbot was piloted to assist teachers with lesson planning, classroom management and subject matter support (Choi et al., 2023).

While the opportunity to streamline curriculum design and lesson planning from the classroom to the system level is promising, it also presents challenges in ensuring the AI models produce high-quality, coherent content. If the models are trained on fragmented or low-quality material—whether in content or suggested classroom activities and practices—they may replicate outdated or subpar material, producing materials that fall short of human-created designs, even if generated more quickly. Therefore, before AI is widely adopted for instructional design, policymakers and educators must ensure that models are trained on high-quality, curriculum-aligned material and that outputs are vetted by expert instructional designers to meet educational standards.

B. Expanding access and achieving complete learning trajectories.

● Enhancing early warning systems

AI also has the potential to expand engagement among various stakeholders in education systems. For instance, automated machine learning and data analytics tools could enable the development of "early

warning systems," which use student wellbeing and performance data to identify those at risk of dropping out or in need of additional support. This type of tool, however, is not necessarily a novelty brought by AI; governments in the Latin America and Caribbean region have already piloted such systems using administrative data and have implemented interventions based on the recommendations of early warning systems (Adelman et al., 2018; Vazquez et al., 2021; see Box 10). Although early warning systems have been explored and implemented for several years in the region, AI-based tools that simplify data analysis and interpretation may lower the threshold for governments and technical teams to adopt these interventions. However, this apparent simplification could make it more difficult for non-technical audiences to understand the algorithmic "black box" behind the tools and engage with them, potentially reducing uptake. Moreover, the inclusion of analytical techniques that are easier to access but less transparent may embed algorithmic biases into the technology and its recommendations, making them harder to identify and correct. Still, reports from international organizations like the World Bank note that AI could be used to set up and deploy these types of interventions (Molina et al., 2024). Whether interventions are AI-based or AI supported, these types of initiatives could potentially help governments identify students at risk of dropping out—which remains a significant challenge in the region. Similarly, AI has the potential to help maximize fairness and effective resource use with regards to other areas of centralized resource allocation, such as textbook distribution and teacher assignment. Although this type of work predates AI, AI can reduce the technical barriers to accessing technology-based administrative support.

Box 10. Early warning systems

School dropout remains a significant challenge that threatens students' ability to achieve continuous, complete and successful educational pathways. While compulsory education laws may help, weak enforcement often limits their impact. In Latin America and the Caribbean, 33% of young people do not complete secondary education (Arias Ortiz et al., 2024a). Addressing this issue requires targeted support, but identifying students at risk is not always straightforward.

Protection systems for educational pathways aim to reduce educational exclusion by creating conditions that enable students to stay in school. These systems also endeavor to reduce learning gaps and early dropout, and to promote equity in access to learning. Protection systems are typically structured around two key components: risk detection, with early warning systems as the central tool, and timely interventions to prevent dropout (Arias Ortiz et al., 2021a). Early warning systems range from simple models that generate alerts based on selected indicators to more sophisticated approaches that utilize machine-learning methodologies (Arias Ortiz et al., 2021a). Recent advances in data availability and the development of predictive AI-driven methodologies have further strengthened these systems, replacing expert-driven models with machine-learning algorithms. While these systems are more common in high-income countries, their application in Latin America and the Caribbean has shown promising results.

For example, in Guatemala and Honduras, researchers tested an early warning system using administrative data to predict early dropouts in primary and secondary schools (Adelman et al., 2018). Using basic demographic, performance and enrollment data, these models accurately predicted about 80% of sixth-grade dropouts within the following year, matching the performance of models used in high-income countries. Further analysis demonstrated that targeting at-risk students identified by these models, rather than relying on broader geographic or demographic targeting, could reduce resource misallocation by 30–80%—assuming the subsequent intervention is effective. In a separate study in Guatemala, coupling these prediction models with an on-the-ground dropout prevention program reduced dropout rates during the transition from primary to lower secondary school by 4%

in schools assigned to the program, and by 9% in schools using it as instructed, at an estimated cost of less than USD 3 per student (Vazquez et al., 2021). Interestingly, much of the program's success stemmed from providing actionable information on how to prevent dropout, rather than solely identifying at-risk students. This finding aligns with the educational pathway protection approach, which emphasizes the complementarity of both components: detection and timely intervention, as identification alone is unlikely to be enough.

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While artificial intelligence offers advantages such as automating analysis and minimizing the need for manual adjustments, its implementation also presents challenges. Issues like incomplete data, lack of representativeness and biases in model development can result in unfair or discriminatory decisions (Sánchez Ávalos et al., 2021). As a result, it is crucial to not only evaluate error metrics at a general level but also to assess them by subgroups to ensure fairness and equity in their application. Additionally, generative AI's ability to produce natural language content could make it easier to communicate findings to stakeholders and provide tailored insights for specific students or subpopulations. However, the success of these systems ultimately depends on the quality of the underlying data, as well as robust governance and policy frameworks for implementing their recommendations. In this sense, early warning systems further exemplify the importance of embedding AI-enabled tools within broader systems that empower stakeholders, rather than replacing their expertise.

● Providing on-time, data-based insights to key stakeholders

Another way AI could enhance engagement and create growth opportunities within education systems is by providing information and synthesized insights to various stakeholders through the automation of data processing and reporting in natural language. For example, AI's unique ability to customize content at scale could enhance existing parent messaging campaigns by tailoring the messages sent. As such, AI-enhanced messaging could go beyond informing parents about specific outcomes to tailoring the information based on available data to highlight what could be most helpful for each individual child. Similarly, AI-based programs could offer constructive feedback and coaching to students at scale—a task that would require significant time if done manually, and which often does not end up happening at all.

Additionally, AI tools can be used to analyze and process audio. These tools can "listen in" on classes and generate coaching summaries that suggest ways teachers can improve their practices for professional development. In contexts where in-depth coaching is rare, and high-quality coaches are unavailable on a large scale, AI-based tools can expand teachers' access to valuable professional development resources to enhance their teaching.

Interventions of this nature are already under development. For example, the M-Power tool uses natural language processing to analyze classroom verbal interactions and provides formative feedback to educators, highlighting areas for potential improvement in their teaching practices. From the student perspective, TeachFX is an application that uses voice AI to automatically assess student engagement and furnish teachers with targeted pedagogical feedback.

Importantly, these interventions imply a level of access—whether to sensitive personal information or classroom recordings— that current interventions do not typically have. This highlights the need to

establish strong data governance protocols as a prerequisite for any such intervention to protect privacy and ensure data confidentiality, particularly for minors within the system.

Reaching historically underserved populations

Finally, AI-based technology has the potential to unlock new opportunities for education systems to reach traditionally underserved or disadvantaged populations. AI tools can translate materials into different languages quickly and on a large scale, including audio and video transcripts. This type of translation may enable education systems that cater to multilingual populations to reach more pupils in their native languages. This is important, given that language diversity exists within individual classrooms as well as across regions. Similarly, text-to-speech features could produce media that increases accessibility, allowing visually impaired learners to benefit from class notes and written materials displayed by teachers. Additionally, AI-based transcription tools that generate both transcripts and summaries may help students who are absent—whether sporadically or for extended periods due to illness or other challenges—benefit from classroom discussions without having to rely on analog and potentially incomplete solutions like classmate notes.

In all, AI-based solutions have the potential to improve accessibility for stakeholders who may have been part of the education system but were not fully served by it. However, as with other AI-based interventions, these enhancements to students' educational experiences depend heavily on the training and development of AI tools. In many cases, unlocking these opportunities will require concerted efforts by governments and industry. For example, while AI tools can theoretically generate automatic translations, if the tools have not been properly trained in the local language, the translation may either be unavailable or of low quality. This is of particular concern for languages spoken by a relatively small number of people, as is common in some regions of LAC. Similarly, there is a growing concern among experts that the lack of integration of indigenous languages into digital platforms (76.9% of online languages correspond to the world's top ten most spoken languages), will contribute to the growing number of endangered languages. According to the latest predictions, by 2100, half of the world's spoken languages will either vanish or be on the brink of extinction.⁵ Thus, though AI tools have the potential to increase the reach of education, policymakers must prioritize careful institutionalization, significant investments in protecting linguistic diversity and local adaptation of tools in order to truly benefit students.

C. Efficiency in service delivery

Generating batch content and executing batch processing

One of AI's strongest comparative advantages, even relative to existing technologies, is its ability to generate batch content and execute batch processes in a replicable manner. These capabilities make it well-suited to integration in centralized education management. AI's unique capabilities could allow governments to train models to replicate best practices in lesson creation. After feeding the right content to the models, they could generate a batch of lessons for a course based on initial guidelines. Applications such as Twee or Eduaide. AI already possess the capability to generate educational content in batches. Educators can input topics, links or keywords, and the application instantaneously produces texts, dialogues, exercises, and questions related to the specified subject matter.

⁵ UNESCO (2023), "A digital future for indigenous languages: Insights from the Partnerships Forum," <https://www.unesco.org/en/articles/digital-future-indigenous-languages-insights-partnerships-forum> (accessed March 28, 2025).

This approach could shift the work of instructional developers towards ensuring that high standards for quality control are upheld, moving their efforts away from ensuring proper formatting and procedural adherence to verifying content accuracy and pedagogical soundness. In this way, AI-enabled replication has the potential to increase productivity at lower costs while still requiring expert human involvement for proper model calibration and quality assurance of the generated output.

● Faster grading and generation of feedback

Another potential use of AI's unique ability to execute batch processes is the grading of assessments on a large scale. This includes the efficient provision of detailed feedback, which is normally a time-intensive task (see Box 11). Through optical character recognition (OCR) features, AI-based tools may recognize patterns in multiple-choice and written assessments, enabling faster grading. These types of tools also promise to centralize the resulting data and identify trends within individual assessments to provide insights for students, as well as aggregated patterns for teachers and policymakers. Similarly, AI-powered audio transcription features could allow future assessment tools to accurately quantify metrics like oral reading fluency through automated data collection, as opposed to relying on human collection, which can be both costly and subject to measurement errors that may vary from student to student or class to class. While these tools may not improve learning outcomes, they have the potential to significantly free up teacher time. In turn, as noted in the previous section on technology in education, when coupled with the right incentives, teachers could divert more attention to student needs that require human interaction.

Box 11. AI for feedback on student writing in Brazil

Providing meaningful, improvement-oriented feedback on student work is key to student growth. However, this activity consumes a significant share of teachers' time, adding to their already extensive responsibilities, and potentially detracting from other critical tasks, such as individualized discussions. Artificial intelligence, with its ability to recognize patterns, classify information and generate tailored responses, might offer a promising avenue to partially or fully outsourcing grading tasks—even for written texts. This would allow teachers to focus on more engaging, high-impact activities.

A study in Brazil tested the use of AI-based marking systems to provide feedback on complex writing tasks for high school students preparing for large-scale standardized assessments (Ferman et al., 2021). The randomized controlled trial spanned an academic year, involving high school seniors who completed five ENEM essay-writing practices on diverse topics. Students in the treatment group used an online platform that delivered instantaneous feedback on features such as word count and spelling errors. The study evaluated two approaches: 1) “enhanced” automatic grading, which used machine learning to categorize essays and provide feedback on syntactic elements like spelling and tone, with human graders offering final scores and detailed feedback on skills like argument quality and coherence; and, 2) “pure” automatic grading, which fully automated grading, and used AI alone to provide predicted scores and pre-selected comments based on the essays' skill ratings.

The study found that both the “enhanced” automatic grading and the “pure” automatic grading resulted in moderate effects on standardized assessment scores across most evaluated skills—including syntactic skills, analytical skills and policy proposal skills. Both approaches yielded improvements of approximately 0.1 standard deviations. Surprisingly, the inclusion of human graders in the enhanced marking arm did not produce additional gains compared to the pure AI-only system, suggesting that the AI tool alone was sufficiently advanced to improve outcomes across a broad range of writing skills.

High compliance among participants contributed to the intervention's success. Over 95% of teachers and about 70% of students consistently used the new tools for each writing activity, with similar adherence across treatment groups. This high uptake resulted in a 30% increase in the number of essays written for ENEM preparation. Moreover, both approaches increased the quantity of feedback students received, including comments provided by teachers through the platform. Notably, both interventions also boosted the number of essays discussed individually with teachers by approximately one-third, countering concerns that AI might replace teacher-student interactions.

Rather than diminishing teachers' roles, both approaches enabled educators to focus on tasks that promoted individualized pedagogy, such as one-on-one discussions about essay quality. This shift highlights AI's potential to constructively complement human educators by automating routine tasks while allowing them to engage in more complex and personalized teaching activities. Furthermore, the lack of additional effectiveness from human graders in the enhanced marking arm relative to the fully automated arm suggests that, in this case, the AI system was sufficiently advanced to replace the need for human grading, thereby improving the cost-effectiveness of the intervention.

Planning and decision-making

Finally, AI tools might enable principals and other mid-level members of educational bureaucracies to become more effective in their roles. AI tools that save time and synthesize the information needed to make planning decisions could achieve this. For example, some AI tools' ability to summarize and optimize information could allow principals to draft timetables adapted to their schools' specific contexts and constraints, write administrative documents and communications in a clear and concise manner, and produce high-quality reports on school activities to share with ministries. uPlanner, a Chilean AI-driven platform, provides predictive analytics to support educational institutions with various administrative functions. These include managing and aligning academic calendars and optimizing the utilization of infrastructure and resources to facilitate informed decision-making that enhances both operational efficiency and educational quality.

Beyond the "assistant" capabilities of AI, its capacity to automate data processing, including analysis and reporting, might help principals and other bureaucrats make sense of large-scale data for local planning. This could be especially important in situations where principals and other stakeholders were previously excluded from such conversations due to low data literacy—despite the potential high value of their input. In this sense, AI tools have the potential to be more beneficial than other technologies for some aspects of school management. This includes the redirection of resources toward more efficient and effective uses, as well as enhancing the capacity of stakeholders to play a leading role in the education planning process.



3.2

Emerging challenges presented by AI

The emergence of AI in education offers new possibilities for both augmenting the benefits of existing technologies and unlocking new opportunities. That said, AI also presents challenges. Policymakers must carefully consider these challenges before implementing AI-based interventions to minimize and mitigate associated risks. Below, we discuss some of these potential risks, which—though not unique to AI—warrant careful attention.

◆ Equity in access to effective tools

AI could widen inequalities if not carefully implemented, particularly in resource-limited environments. Wide differences in access to required enabling technologies at the household- or school-level are likely to translate into inequities in terms of who can benefit from AI-enabled opportunities. Policymakers should consider the fact that access to AI can vary depending on students' and schools' socioeconomic profiles, and this differences in access might risk further widening inequalities in opportunity. Addressing the digital divide is crucial for equitable access to AI's benefits.

◆ Plagiarism

AI-based tools with generative capabilities like those designed to assist educators and bureaucrats in making their work more effective and efficient are also accessible to students. This creates significant opportunities for plagiarism, particularly in unmonitored settings such as at home. For instance, in the United States, a recent analysis revealed that—even in these tools' relatively nascent stages— AI use was detected in about 10% of assignments, with 3% being almost entirely AI-generated (Prothero, 2024). While AI detection tools are currently available, as generative technologies continue to advance there is a growing risk that detectors may eventually fail to identify such instances. Policymakers and teachers must make deliberate decisions on this issue with regards to when and how they address plagiarism. Policymakers and teachers should also wrestle with whether some classroom work and assignments should be adapted to incorporate AI as a productive element of the learning process.

● Bias in AI-based outputs

AI models are trained using a pre-existing “corpus” of data. If these data are biased or inaccurate—such as when they reflect only majority opinions or include false or misleading information—they can result in skewed outputs and automated decisions. As a matter of course,

these outputs and decisions can then disproportionately affect underrepresented communities and amplify distorted or inaccurate ideas. It is important to prevent algorithms from being trained with biases that replicate and extend inequality. For instance, predictive algorithms used in the US criminal justice system to forecast the likelihood of reoffending have incorrectly labeled African American defendants as twice as likely to reoffend compared to their white counterparts (Angwin et al., 2016). These predictive algorithms are conceptually similar to early warning systems in education. Similarly, algorithms used by the technology industry for employment recruitment have exhibited bias toward women (Dastin, 2018). It is important that efforts to actively correct such outputs be approached thoughtfully. Human-led interventions should be led by a diverse team of experts so that overcorrection does not occur, and additional biases are not introduced, particularly in a field like education (Shamim, 2024).



It is important to prevent algorithms from being trained with biases that replicate and extend inequality.



Algorithms must be transparent and accountable. It is important that the people who interact with AI systems understand how these systems affect them. It is also vital that people have recourse when things go wrong, as the companies and agencies that make AI must be held accountable for their products. Attending to this challenge calls for periodic algorithmic audits of Automated Decision Systems (ADS). These audits should increase the internal capability of public agencies to evaluate the systems they build or procure and enable them to build or procure more effectively in the future. Frequent audits can anticipate issues that may arise from undesirable situations, such as incorrect benefits allocation or due process violations. Ideally, audits ensure greater accountability by designing a useful and ongoing method for third parties to review and assess ADS so that problems can be solved or mitigated. Finally, the public must have a meaningful opportunity to respond to and, if necessary, dispute the use of a given system or the guidelines used for its development by a public agency (Aránguiz Villagrán, 2022).

● Appropriate training of AI models for education-specific purposes

AI models are trained using data and will generate outputs based on that training. If data that reflects outdated pedagogical practices is used to train AI models meant for educational purposes, these models could automate ineffective teaching methods. Therefore, AI tools must align with both national curricula and teachers' pedagogical needs. Additionally, it is crucial that these models are trained with materials that follow best pedagogical practices, ensuring the outputs are grounded in human expertise and effective teaching principles.

● Regulation and privacy

AI's rapid development has been outpacing regulatory frameworks, raising concerns around data privacy, the use of copyrighted or private content to train AI without consent, and the management of “black box” of AI algorithms. Governments need to establish clear policies regulating AI's role in education, ensuring

ethical use, data protection and capacity building for effective implementation. Furthermore, cross-border and cross-sector cooperation to regulate AI in education is crucial to harmonizing policies among countries. The private sector must also be involved to ensure the ethical implementation of AI tools. Last year, Italian regulators briefly restricted access to ChatGPT due to concerns about its compliance with European data protection laws. The authorities pointed to problems with verifying users' ages, using personal information without permission to train the AI chatbot and a general lack of clarity with regards to how the system handles data. This incident underscores the challenge of regulating rapidly advancing AI technologies within current legal frameworks.

Capacity building within systems

Even when effective AI interventions have been identified, governments need to build institutional capacity and AI fluency. Governments must do this to ensure that future users not only understand AI's functionalities, but also how the algorithms aggregate data and can replicate biases and false information. A lack of proficiency in how these tools work and derive their outputs may lead untrained users to assume the accuracy and veracity of results, even when this isn't the case. To prevent these problems, governments should implement support and monitoring systems to oversee AI tools from first inception through planning, design and execution. Some tools have been developed to assure consistency and responsibility in the process (Sánchez Avalos et al., 2021)

A concrete example of the need for institutional capacity and AI fluency comes from the United Kingdom. In 2020, the UK government used an algorithm to assign students' grades for secondary leaving examinations. This algorithm heavily favored students from elite schools while disproportionately lowering scores for students from disadvantaged backgrounds. This case illustrates the dangers of deploying AI without sufficient institutional capacity and AI fluency among decision-makers. Policymakers and educators trusted the algorithm's outputs without fully grasping its biases. This in turn lead to unfair and unreliable outcomes.

Table 2. Summary of potential uses of artificial intelligence in education to advance policy goals related to learning, access and efficiency

POLICY GOAL	AI-SPECIFIC ADVANTAGES CAN AUGMENT DIGITAL TRANSFORMATION	POTENTIAL AI USES	POTENTIAL RISKS AND CHALLENGES
 MAXIMIZING LEARNING IN THE CLASSROOM	Mass production of content following specific patterns. Generation of new, tailored content in both written and media formats. Expanded capacity for data processing, including analysis and reporting.	Creation of practice problems that support additional practice across a wide range of proficiency levels. Generation of tailored lessons in written and media formats to address specific gaps for each student. Chatbots that promote academic and non-academic outcomes, such as mental health support. Virtual assistants for teachers to enhance lesson planning and classroom management practices. Cost-effective creation of multimedia supplements for teacher instruction.	Platforms that track student assessment data must have robust privacy and data management protocols to keep children safe. Targeting instruction and practice sets to pupils' specific levels carries the risk of bias in how certain sub-groups are addressed, depending on the algorithm. If the targeting decisions are visible beyond the student and teacher, they could lead to stigmatization of the lowest performing pupils. The training of AI models must ensure that any multimedia outputs created to complement lessons are both high quality and age appropriate.
 EXPANDED ACCESS AND COMPLETE TRAJECTORIES	Expanded capacity for data processing, including analysis and reporting. Mass translation of documents. Generation of new, tailored content in both written and media formats. Analysis and processing of audio.	More sophisticated and comprehensive early warning systems to prevent student dropout. Automated analysis to optimize the fair distribution of resources, such as textbooks and teacher assignments, reducing technical barriers and human biases. AI-generated coaching for teachers who previously lacked access to consistent, high-quality support from human coaches. Translation of materials to reach multilingual learners in their native languages, enhancing inclusion of diverse populations. Creation of accessible materials using text-to-speech tools or transcription services, supporting marginalized groups such as visually impaired students or those with frequent absences.	The training of early warning systems could result in systematically biased recommendations for certain sub-groups of students. Any use of audio or video recordings to improve teacher practices must be supported by robust data management protocols to ensure child privacy and safety.
 EFFICIENCY IN SERVICE DELIVERY	Optical character recognition that reads images and processes the resulting data on a large scale. Analysis and processing of audio. Expanded capacity for data processing, including analysis and reporting.	Batch lesson generation to streamline lesson writing for structured pedagogy interventions, reducing the need for large instructional design teams and improving quality while lowering costs. Automated grading and tailored feedback for written assessments, including multiple-choice and short-answer questions, as well as oral reading assessments. Time-saving administrative tools to assist principals with scheduling, drafting documents and creating reports tailored to school needs. Automated data analysis and reporting to support data-driven planning decisions by educational leaders, especially when data literacy is low.	Just as AI can make grading and providing feedback faster for teachers, it may also enable students to engage in more sophisticated forms of plagiarism, requiring an active policy response and engagement plan from schools and education systems. Shifting time away from routine tasks may not necessarily result in more time spent on desirable activities like instruction or personalized attention, potentially limiting the returns on the investment in AI. Overreliance on AI for report generation and data analysis could lead to school staff becoming less personally attuned to the situation on the ground.

4.

Harnessing
technology and
AI for education





Extensive scholarship on the subject shows that fidelity to design and quality of implementation are critical to the success of technology-based educational programs. Research demonstrates that low fidelity to the original design of technology-based programs can compromise intended outcomes. Furthermore, even minor deviations can disrupt elements that are crucial for learning gains (Durlak & DuPre, 2008). Similarly, the quality of implementation—including factors like teacher training, infrastructure and student engagement—has a direct impact on program effectiveness (O'Donnell, 2008). To address these challenges, policymakers should consider using a conceptual framework to provide education systems with structured, evidence-informed, yet straightforward approaches to creating and implementing technology-based programs. Such a framework would enable the identification of key components and mechanisms, ensuring that the use of technology is aligned with intended educational goals.

Building on the evidence reviewed in the previous sections, which examined how technology and AI can help address key educational challenges, this section focuses on translating those policy lessons into actionable strategies for program design and implementation. For policymakers looking to improve education using digital tools, it is critical to assess the inputs necessary to affect different interventions. As such, policymakers should consider both the technological capabilities their education systems have and the level of investment required to meet the minimum conditions for success.

This section introduces a framework to guide the design, implementation and sustainability of programs that integrate technology in education on a large scale. It incorporates insights from research reviewed in the previous section to describe specific uses of technology and AI that can help countries to achieve one of the three development objectives listed in the introduction of the report. Then, it outlines the enabling conditions necessary to support common types of interventions and successfully attain intended objectives. This section also offers a systematic approach to monitoring and evaluating product results and outcomes, fostering more scalable and impactful technology-enhanced learning experiences. By establishing a clear understanding of the current state of enabling conditions in their systems, policymakers can determine which interventions they are ready to implement and which require further investment to become viable. The cost-effectiveness of digital initiatives is closely tied to these enabling conditions. Insufficient infrastructure can drive up costs, while existing but underutilized resources can be capitalized on to reduce expenses.

4.1

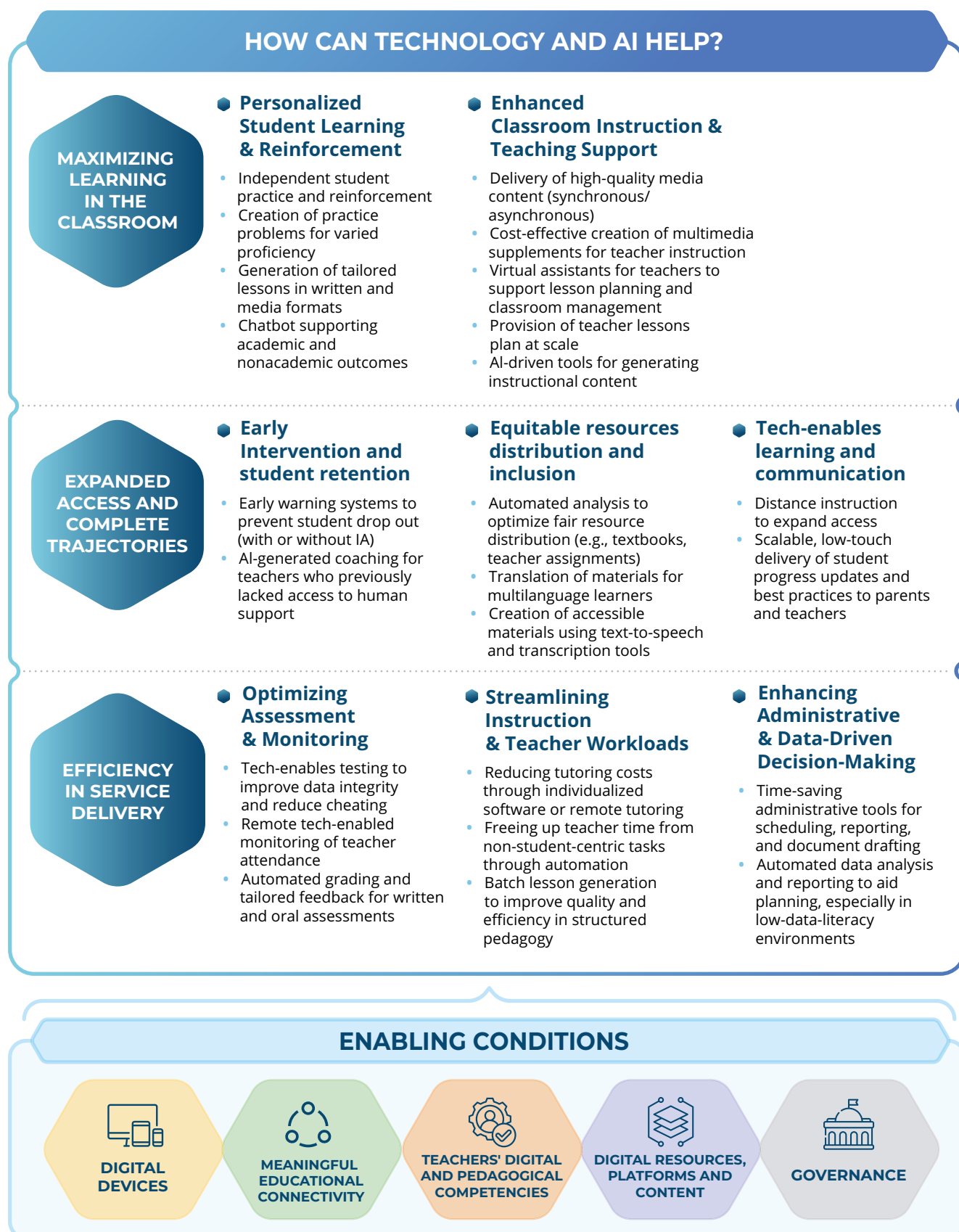
A framework for scalable impact

Our framework is described in Figure 1. This conceptual framework categorizes technology and AI-driven interventions into three main policy goals in education: 1) maximizing learning; 2) expanding access and the completion of learning trajectories; and 3) enhancing efficiency in service delivery. To improve learning, interventions focus on personalized student support, enriched classroom instruction and scalable teaching resources—such as AI-driven tutoring, adaptive learning tools and automated content generation. To expand access and completion, strategies include early warning systems for dropout prevention, AI-powered translation and accessibility tools, and scalable communication channels for parents and educators. Finally, to enhance efficiency in delivery, interventions utilize digital tools for assessments, teacher workload reduction and data-driven decision-making. These types of interventions include remote monitoring, AI-generated lesson planning and administrative support tools. By aligning these interventions with resource availability, policymakers can effectively integrate technology to create equitable, scalable and cost-efficient educational improvements.

Programs that use technology require five enabling conditions: digital devices, meaningful educational connectivity, digital resources and platforms, teachers' digital and pedagogical competencies, and governance.⁶ A robust governance is needed at the system level and includes institutional capacity, effective management, information systems and sustainable financing. Without these elements, education systems cannot support and expand education technology initiatives. All together, these five key enabling conditions are closely interrelated and can ensure not only access to technology but also its effective integration, which creates the conditions for systems to achieve policy goals.

⁶Other conceptual frameworks have been developed to help policymakers integrate technology into their education systems and all have one thing in common: the importance of addressing not only technological infrastructure but teachers, content and institutional capacity. For example, the 2022 Education Transformation Summit identified meaningful connectivity, capacity and content as foundational pillars of digital learning. Similarly, the 2024 Framework for System Transformation, developed by UNESCO, UNICEF, ITU and GPE, incorporates these pillars into its six core focus areas for advancing digital transformation in education (UNESCO, 2024). Our framework is different because it links inputs with mechanisms and specific development objectives.

Figure 1. Framework for integrating technology and AI in education at scale





Digital devices

Frequent and reliable access to adequate digital devices is a fundamental requirement for students and teachers to engage effectively in digital learning environments. Without this essential foundation, achieving broader digital transformation of education becomes unfeasible. However, access alone is not enough—the interplay between availability, quality and pedagogical integration determines the actual impact of digital tools on teaching and learning. According to the PISA 2022 Information and Communication Technologies Framework, the way technology is used in classrooms is significantly influenced by its availability, accessibility and quality. Therefore, decisions regarding devices and other technological tools should be driven by pedagogical objectives, rather than allowing technology to dictate educational strategies. For instance, specific learning needs in subjects like mathematics, science and writing should determine the type and specifications of devices introduced into classrooms, ensuring they effectively support student outcomes.

Two critical factors must be considered when integrating digital devices into educational environments: quantity and specifications. The device-to-user ratio influences how technology is used. Over time, educational systems have shifted from dedicated computer labs to one-device-per-student models, and more recently to shared mobile solutions, such as device carts⁷ that lower costs while maintaining accessibility. The choice among these models depends on pedagogical goals, but it is essential to recognize that the availability of devices directly affects the types of digital learning experiences that can be implemented. Additionally, device specifications determine the range and relevance of learning activities. For example, touchscreen devices may be necessary for developing early writing skills, while older or poorly maintained devices can lead to compatibility issues that limit their effectiveness. Typically, tablets are used for early-grade students, while laptops are provided to older students and teachers. In Uruguay for instance, plan CEIBAL follows that model, as tablets are provided for 1st and 2nd graders and laptops for students from 3rd grade through secondary education (Ceibal, 2024).

When integrating AI-powered solutions into education, it is essential to consider the technical capabilities of the devices students use. The requirements may vary depending on whether the AI tool runs on the cloud or directly on the device. Cloud-based solutions generally require a stable Internet connection and a compatible browser, making them more accessible than device-based solutions for schools with limited hardware resources. In contrast, locally executed AI applications demand higher processing power, memory and storage, which can be challenging for schools with older or lower-performing devices.

Beyond personal devices, other technological tools play a crucial role, especially in experimental learning environments that encourage hands-on, creative problem-solving. In such programs, digital devices exist within a broader educational ecosystem, complemented by development boards, electronic kits, physical-chemical sensors, robotics kits, 3D printers and drones. These tools support project-based learning, enabling students to explore, create and share knowledge through hands-on experimentation. Design-thinking methodologies and maker principles foster collaborative learning environments, where students engage in problem-solving, critical thinking and innovation. Integrating these tools effectively requires purposeful curriculum alignment, ensuring that hands-on experiences reinforce conceptual understanding rather than serving as isolated activities.

⁷ Device carts are mobile storage units designed to securely hold, charge and transport electronic devices such as laptops, tablets or Chromebooks within educational or professional settings. These carts typically feature multiple slots or shelves for organizing devices, built-in charging stations to ensure they remain powered and locking mechanisms for security.

Finally, the successful integration of devices and other digital tools requires a long-term strategy for deployment, maintenance and sustainability. Simply distributing devices without a structured plan for ongoing support, software updates and replacement cycles is unlikely to yield positive outcomes. A robust maintenance system must be in place, including technical support protocols, device protection policies and continuous user assistance. Without these elements, digital learning initiatives risk becoming obsolete or underutilized over time (Arias Ortiz et al., 2020b). Ensuring that devices and tools are not just available but also functional, relevant and integrated into pedagogical practices is essential to maximizing their educational impact.

Meaningful educational connectivity

Having access to devices alone is not enough; meaningful educational connectivity has become a key enabling condition for digital transformation in education (DTE). In classrooms, the focus cannot just be on having Internet access but also on ensuring a reliable, high-quality connection that aligns with pedagogical needs. The technical requirements for school connectivity vary depending on its intended educational applications. For instance, lesson planning can require no Internet connectivity or different bandwidth and stability than real-time video interactions between students and remote instructors.

While connectivity needs differ based on usage, establishing minimum quality standards is essential to ensuring digital transformation efforts are effective. These baseline criteria help educational authorities design policies and programs that prioritize not just access (i.e., whether a school has Internet) but also the adequacy and quality of the connection for teaching and learning. In this context, the concept of meaningful educational connectivity can set clear benchmarks for school connectivity services and establish minimum thresholds to ensure technology effectively supports learning. Two fundamental dimensions of this concept are Internet speed and coverage within learning spaces, both of which are critical for enabling engaging, technology-enhanced education.

With respect to speed, the Interinstitutional Group for Connectivity in Education of Brazil aligns with international standards in its establishment of a minimum of one megabyte per second (MBps) per student during the largest school shift to support meaningful teaching and learning. To illustrate what this allows, three usage scenarios can be considered: 1) all students in a school could simultaneously engage in general internet use, such as web searches and reading news; 2) half of the students could be online at the same time, with one in three participating in video activities; or 3) a quarter of the students in a shift could engage in video activities simultaneously (GICE, 2022).

Using AI in educational settings requires higher-quality connectivity. As such, policymakers must consider specific Internet speeds and latency (the amount of time it takes a data packet to go from one place to another), depending on the type of activities performed. For example, when using chatbots, a minimum speed of 5 megabits per second (Mbps) and a latency of no more than 100 milliseconds (ms) is recommended. However, for more advanced activities such as AI-driven videoconferencing or voice assistants, these parameters should be at least 10 Mbps with a maximum latency of 50 ms.

In addition to meeting minimum speed parameters, the optimal approach to ensuring that the network effectively supports student needs in a cost-efficient manner involves understanding its usage patterns. Implementing network monitoring tools enables continuous performance evaluation, ensuring that resources are neither over-provisioned, leading to unnecessary costs, nor under-provisioned, which could

impair educational activities. In the case of CEIBAL, Uruguay, where Internet access is centrally managed, the logic behind the contracted bandwidth aligns with the specific demand of each educational center, enabling adaptive provisioning based on actual usage data. This dynamic allocation strategy is critical to optimizing infrastructure investments and ensuring reliable access to educational resources.

The speed of access is also determined by the type of infrastructure available in each region. In areas with fiber optic coverage, maintaining high-speed connectivity is relatively straightforward. However, in rural and remote schools where fiber or cable deployment is unfeasible, alternative solutions such as satellite, microwave links or mobile networks must be considered. Additionally, partnerships with public and private telecommunications providers play a critical role in ensuring scalable, high-quality connectivity across all schools.

An often overlooked but crucial aspect of connectivity is coverage within educational spaces. Ensuring strong and consistent signal strength is just as essential as meeting speed requirements. Without full coverage throughout the school, Internet access cannot be effectively utilized to enhance learning. Connectivity must extend to all learning areas, enabling students to securely access educational resources from anywhere on campus and ensuring that the available bandwidth is fully utilized. According to MegaEdu, a Brazilian nonprofit organization dedicated to providing high-speed internet access to all public schools in Brazil, signal strength should exceed -70 decibel relative to milliwatt (dBm) in all educational spaces, which can be achieved typically by deploying one access point (AP) for every two classrooms (MegaEdu, 2024).

Maintaining connectivity infrastructure is not a one-time effort but requires continuous oversight and management. Establishing and closely monitoring Service Level Agreements (SLAs) is essential to ensuring consistent service quality (Arias Ortiz et al., 2020b). Regular performance monitoring helps track Internet usage intensity in classrooms, identify potential issues and generate alerts for timely maintenance. These proactive measures help maintain a stable and high-performing network, ensuring that students and teachers can rely on connectivity as an integral part of the learning process.



Digital resources, content and platforms

Digital resources, platforms and content are essential to enabling the digital transformation of education, as they expand opportunities for personalized learning, skill development and student engagement while providing tools for teachers to monitor progress. In some cases, these digital assets play a role comparable to that of textbooks in traditional education. As such, their development and content must be rigorously reviewed so that quality is assured. In addition, integration must be carefully planned. Given the wide variety of platforms, software and content available—each serving distinct functions—it is essential to strategically align these tools with pedagogical goals, ensuring they meet the diverse needs of students and teachers while remaining adaptable to different educational contexts.

One of the most critical categories of digital resources is learning platforms, which deliver educational content, offer personalized exercises, track student progress and support specific subjects or skills. One type of learning platform is a learning management systems (LMS). LMS systems distribute content, assignments and grading, and can also offer communication tools for remote interaction, assessment platforms to evaluate student performance and content repositories that provide supplemental learning materials. These resources can take various forms, such as open educational resources (OER), educational games, e-books and online portals, each contributing uniquely to the broader goal of enhancing teaching and learning.

There are two main elements to consider when thinking about resources and content: 1) they should be high quality, relevant and aligned with the curriculum; 2) they should use data and features to adapt to different learning needs.

First, high quality content is paramount. High-quality resources should be accurate and up to date. They should support deep learning, critical thinking and engagement, rather than just providing superficial or fragmented information. A well-designed platform ensures that students receive reliable and pedagogically sound materials that enhance their learning experience.

In a market as vast and diverse as digital educational platforms, carefully assessing the quality of a platform is not an easy task. This is particularly true with the latest AI-driven developments in educational platforms. With countless alternatives available, it is essential to thoroughly evaluate platforms before committing to one. Some platforms may lack pedagogical soundness, offer poor user experience, or even be "vaporware"(software that is marketed but never fully developed or functional). Testing and piloting platforms before adoption can help identify which truly meet educational needs. In the United States, organizations such as Common Sense Media⁸ play a key role in evaluating the quality of educational platforms, providing ratings and reviews based on factors like effectiveness, engagement and privacy standards. Government certification of platforms help ensure quality and reliability. For example, in Europe, initiatives such as Germany's DIN ISO 21001 standard for educational organizations enforce quality standards. Implementing similar certification initiatives in Latin America and the Caribbean could be highly beneficial, as they would enable educational institutions to access validated, high-quality digital tools that effectively support teaching and learning. In this context, initiatives like UNICEF's [EdTech for Good Framework](#) provide valuable guidance for identifying and evaluating high-quality ed-tech solutions. This framework establishes key criteria—including safety, impact on learning, accessibility and scalability—and offers a structured approach to assessing digital learning platforms. Its Learning Cabinet serves as a curated repository of rigorously vetted ed-tech solutions, ensuring that digital platforms contribute meaningfully to learning outcomes while upholding standards of equity, security and effectiveness. Regarding data safety, it is worth highlighting that the initiative emphasizes how platforms should notify users about the collection of their personal data and the purpose of use. This notification ensures compliance with privacy regulations and promotes transparency. The framework also assesses data protection protocols, particularly for AI-driven platforms, ensuring user privacy and data security, and implements industry-standard controls to protect confidentiality, integrity and information availability (see section IV.1 for further details on data security). As AI-driven educational platforms continue to evolve, integrating principles from initiatives like the EdTech for Good Framework can help policymakers navigate the complexity of the digital learning ecosystem and foster responsible innovation in education.

Resources need to be high-quality but also aligned with curricular standards and students' cultural and contextual realities. This alignment is crucial as it ensures that the content remains both relevant and engaging, and that students can foster a deeper connection with the materials. This is particularly important for learning platforms and digital content, where the challenge lies in adapting existing solutions to local needs and characteristics. The successful use of these resources largely depends on how teachers incorporate them into their pedagogical practices. If high-quality, well-aligned materials are incorporated,

⁸ Other organizations in the US provide guidance to educators and institutions so that they can make informed decisions about technology integration. These organizations include EdSurge (which provides reviews, research and insights on ed-tech products); ISTE's (the International Society for Technology in Education) Seal of Alignment. This seal certifies ed-tech tools and resources that align with ISTE's standards for effective digital learning. Finally, Digital Promise's Research-Based Design Product Certification recognizes ed-tech products that are grounded in science learning and demonstrate effectiveness.

the teaching process can become more dynamic and adaptable. It is also essential that platforms be intuitive and easy to navigate for both students and teachers. Simple interfaces, clear instructions and readily available technical support can significantly increase usage and effectiveness. The more seamlessly these tools can be integrated into everyday teaching and learning activities, the more likely they are to have a lasting impact.

The second aspect is that digital resources must be inclusive and adaptable to diverse student needs. Features such as screen readers, alternative text, voice recognition and multilingual support help ensure that all students, including those with disabilities or language barriers, can fully engage with digital learning experiences. Digital resources, therefore, are not just tools for learning but also powerful instruments for fostering greater inclusivity in education.

Data utilization is another key feature of effective digital learning environments, particularly for learning platforms. Many platforms use adaptive learning technologies to personalize content based on student performance, ensuring that learners receive tasks that are appropriately challenging for their current abilities. For instance, adaptive learning platforms adjust the difficulty of tasks in real-time, optimizing the learning experience. Even platforms that are not inherently adaptive can still provide valuable data, offering insights into students' progress and identifying areas where they may be struggling. This data-driven approach allows teachers to monitor individual progress, identify learning gaps and adjust their teaching strategies accordingly. Personalization enhances learning outcomes and encourages students to take an active role in their education. When students are engaged with content that aligns with their specific needs, they are more likely to stay motivated and achieve deeper understanding.



Teachers' digital and pedagogical competencies

Research has demonstrated the significant potential of technology to strengthen student performance in some cases and has highlighted that success largely depends on how technology is used in the classroom (OECD, 2005; United Nations, 2022; UNICEF, 2022). In order to reap the potential benefits of technology in the classroom, education systems should ensure that teachers hold digital and pedagogical competencies that enable them to integrate technology effectively into their teaching practices. These competencies are also vital for teachers to successfully implement innovative and inclusive classroom strategies. In the context of digital transformation of education in the classroom, the teacher's role takes on renewed and central importance. They are the ones who must select, manage, create and share high-quality digital resources that align with pedagogical objectives and meet the specific needs of their students (Redecker, 2017). Teachers not only remain the primary implementers of curricula but also must act as designers of learning experiences that effectively integrate the digital world.

In that sense, policymakers are faced with the challenge of how to support teachers develop the skills necessary to foster learning for their students. Two important considerations for achieving this goal are: 1) defining, assessing and supporting the development of these competencies; and 2) integrating digital tools with pedagogy while ensuring an ethical and equitable implementation.

With regards to the first consideration, assessing teachers' digital skills is essential for effective digital transformation in education. A good assessment can provide valuable insights into educators' current levels of digital competence and can highlight areas that require further development. At the same time, these assessments can equip policymakers and education leaders with data to inform strategic decisions.

The Guía Edutec [Edutec Guide] is an example of such a tool, as it offers valuable feedback to teachers and school leaders. Originally developed by the Center for Innovation of Brazilian Education (CIEB) and further adapted by Fundación Profuturo and IDB, it has been used by over 33 000 teachers and 700 schools in Latin America. It includes two components: a self-assessment questionnaire for teachers to evaluate their digital skills, and a diagnostic tool to assess schools' technological adoption.⁹

Educators who choose to use the Guía Edutec receive individualized feedback reports, which indicate their level of digital competency and classroom technology adoption. These reports also provide free, accessible resources tailored to teachers' specific needs, which help them strengthen their skills. Additionally, aggregated data from these assessments give education authorities a clear and updated picture of the system's digital readiness, identifying gaps and areas for improvement (Gottlieb et al., 2024). When policymakers have access to this type of information, they can design targeted professional development initiatives and allocate resources more effectively to support teachers in developing these competencies. As such, programs like this can enhance teachers' digital and pedagogical skills while supporting the integration of technology in classrooms.

New developments in AI could play a crucial role in supporting teachers to effectively integrate technology in the classroom. As was discussed in previous sections, some AI tools have the potential to enhance teacher training processes and strengthen instruction at the classroom level. Furthermore, some tools can provide continuous professional development for teachers through personalized courses, virtual assistants and learning platforms that assess and analyze their interests and areas for improvement. These tools can offer tailored recommendations, keep educators updated on technological trends and suggest innovative teaching strategies.

Nevertheless, educators must be empowered to evaluate and adapt AI tools to their teaching needs rather than relying on automated or general recommendations. For example, integrating technology and AI, particularly chatbots, into the classroom requires understanding their potential benefits and limitations, which also requires understanding how chatbots can complement human interactions. It is important to emphasize that purely human interactions are highly effective in fostering deep social and emotional learning, as they are grounded in empathy and contexts that technology cannot replicate. That said, students cannot always have access to these types of interactions due to personnel shortages and issues with consistency (Miao et al., 2020). **Hybrid models**, which combine human oversight with the efficiency of automation, have the potential to capitalize on AI's ability to handle repetitive tasks while maintaining a human touch when nuanced decision-making or empathy is needed (Holmes et al., 2019). Finally, **autonomous bots** use advanced AI to provide instant, tailored responses to students without requiring human intervention. These bots have the potential to offer personalized learning support on a large scale (Luckin et al., 2016).

Educators can develop strategies that utilize the unique strengths of both humans and AI, ensuring technology enhances learning rather than replacing valuable human connections. This approach must also include training on data privacy, security and bias mitigation to promote responsible AI use. Additionally, program design should prioritize supporting all educators—particularly those in underserved areas—to avoid exacerbating existing educational inequalities.

⁹ Guía Edutec was developed by CIEB in 2017 in Brazil. With support of IDB and Fundación Profuturo, it was translated to Spanish, English and French, with its code made available open source in GitHub. For more details: <https://guiaedutec.com.br/>



Governance

Governance and systemic planning are key to ensuring schools effectively use technology to enhance educational outcomes (Kennisset, 2013; 2015). Governance encompasses the normative and institutional elements that shape the digital transformation of education in schools and at the systemic level. This involves establishing a legal and institutional framework that defines the roles and responsibilities of various actors, alongside a strategic vision that sets clear objectives, allocates resources and guides the process of digitally transforming education.

A strong governance structure relies on three aspects: 1) institutional design; 2) use of quality data supported by strong management and information systems; and 3) sustainable finance.

Institutional design

Ensuring governance mechanisms at all levels of the education system—from classrooms and schools to national agencies—is essential for achieving the intended goals of technology in education.

Effective governance within schools ensures that technology is not merely introduced but is also strategically integrated into teaching and learning processes to enhance student outcomes. School leaders play a pivotal role in setting clear policies, providing professional development for teachers and fostering a culture of innovation and responsible technology use (OECD, 2021). At the classroom level, governance involves teachers making informed decisions with regards to digital tools, ensuring their alignment with pedagogical goals and maintaining the ethical and secure use of technology to protect student data and privacy (UNESCO, 2022). Schools that implement structured digital strategies, such as Finland's digital pedagogy framework and Singapore's FutureSchools initiative, demonstrate how well-governed technology integration can lead to enhanced teaching effectiveness and student engagement (European Commission, 2019).

At the system level, institutions must be structured to foster innovation on a large scale, as vast and complex institutions are often resistant to change. Traditionally, specialized units in ministries of education have taken on the task of designing structural changes to educational institutions. However, successful examples show that establishing independent agencies dedicated to the digital transformation of education can be an effective alternative. These agencies, which work closely with the education system, are more agile and responsive to the exigencies of educational transformation. Agencies like Educ.AR in Argentina, CARNET in Croatia and CEIBAL in Uruguay were specifically created to support the digital transformation of education. Their work demonstrates that independent institutions can have a significant impact (Arias Ortiz et al., 2020b; Dellagnelo, L., 2023).

In some cases, regulatory changes might be needed to address issues such as ethics, data privacy and cybersecurity. These changes include establishing regulations that are necessary to ensure interoperability, security, privacy and data management—which are critical components of the digital transformation process. The increasing integration of technology in education has resulted in structural changes in educational governance, moving from formal government oversight to a broader range of private, international and non-governmental actors working in networks (Ball, 2012). To prevent the misuse of educational data by these new non-governmental actors, it is essential to define legal frameworks and governance structures that guide the management and the use of data responsibly.

Ensuring proper oversight requires defined protocols that align with ethical standards and safeguard data integrity. Educational platforms collect and share vast amounts of student data, so strict security measures must be put in place to protect sensitive information. Compliance with data privacy laws and best practices ensures that personal and academic records remain secure while maintaining student trust in digital education initiatives. In addition, ethical considerations regarding data privacy and fairness must be addressed, particularly with regards to AI-powered learning systems. Transparency and safeguards are essential to prevent biases in content recommendations or assessments. Platforms must also comply with data protection regulations, ensuring that student information is secure and only accessible to authorized users.

To support these efforts, it is necessary for ministries of education to invest in training their personnel and incorporating new specialized experts into decision making who can provide strategic guidance during the transformation processes (Arias Ortiz et al., 2021). For example, the Chilean Ministry of Education developed an initiative to train school leaders in digital transformation. The initiative provides principals and regional education officers with skills in technology integration, digital governance and strategic planning for ICT implementation in schools (Ministerio de Educación de Chile, 2021). Similar efforts have been conducted in France and Finland. The French Ministry of National Education has established leadership development programs for ministry staff and school principals focused on digital transformation. These programs cover topics like cybersecurity, digital policy implementation and managing educational data (Ministère de l'Éducation nationale, 2022). By training personnel and working with specialized experts, policymakers can ensure a robust framework for managing digital transformation effectively and ethically.

● Educational management through information systems (EMIS) for data-driven decision making

An important element of the institutional capacity to support and manage digital transformation is the existence of data systems that can organize, analyze and distribute information across the education system.

EMIS influence every aspect of public education from early childhood through secondary education. Using technology for management offers significant efficiency gains by streamlining administrative processes, improving decision-making and optimizing resource use. With access to real-time data, policymakers can develop more effective strategies that ensure the efficient allocation of human, financial and material resources while promoting equity (Arias Ortiz et al., 2021b). For teachers, EMIS provide timely, high-quality information that supports teaching and learning by tracking attendance, student performance and other indicators. This then enables teachers to closely monitor at-risk students and offer them personalized support. Additionally, automating administrative tasks helps reduce the time teachers and principals spend on paperwork, allowing them to focus more on students.

For an EMIS to have high impact, it must establish a strong foundation: primarily through unique identifiers for buildings, schools, positions, human resources and students. These identifiers should be connected to associated data, such as attendance, grades, retention rates and sociodemographic details for students,

¹⁰ A well-integrated digital learning ecosystem requires interoperability, ensuring that various platforms, assessment tools and content repositories can communicate seamlessly. This allows for better data tracking, cross-platform compatibility and a more cohesive learning experience. The ability to share student data across systems enables educators and administrators to make informed, data-driven decisions, improving overall learning outcomes.

initial and successive training for teachers, detailed plans, works and maintenance histories for buildings, and so on. It is also vital that education systems achieve interoperability between processes.¹⁰ In all, these elements allow for the digitalization and automation of key functions in the day-to-day management of education systems. These functions include assigning students and teachers to schools, protecting educational pathways, reporting to parents and managing supplementary services for students, such as scholarships, transportation and school meals.

The role of EMIS is particularly critical in the process of digital transformation. By integrating classroom-level data into broader education management systems, EMIS can identify gaps in connectivity, devices or teacher training that hinder effective digital adoption. This alignment ensures that decisions at the system level directly support and enhance classroom conditions, fostering a cohesive approach to digital transformation. For example, EMIS can help allocate resources to the schools and classrooms most in need, ensure timely delivery of digital content and devices, and monitor the implementation and outcomes of technology-enhanced teaching practices. In this way, EMIS serves as a bridge between high-level policy goals and the realities of day-to-day classroom implementation, ensuring that digital transformation initiatives are both targeted and impactful.

To assist education systems in the LAC region to assess the level of development of their EMIS, the Inter-American Development Bank (IDB) has developed a diagnostic tool that provides education systems with a clear snapshot of the maturity of their EMIS across five key management processes: 1) physical infrastructure and equipment; 2) educational institutions; 3) human resources, budget and finance; 4) students and learning; and 5) strategic management tools. The IDB diagnostic tool also assesses two foundational conditions necessary for a robust EMIS: 1) technological infrastructure; and 2) governance and institutional frameworks. Understanding a country's starting point is crucial to designing and implementing relevant digital education policies. It is also essential to achieving set objectives.

● Ensuring the financial sustainability of digital tools

Finally, achieving the sustainable and efficacious use of digital tools in an education system requires a long-term commitment to both financial and human resources. The costs associated with the use of technology fall into two main categories: capital expenditure (CAPEX) and operational expenditure (OPEX). CAPEX covers the initial investments needed to establish the digital ecosystem, including infrastructure development and teacher training. OPEX accounts for the ongoing expenses required to manage, maintain and update these systems. A common challenge in policy planning is the tendency to prioritize CAPEX while underestimating the long-term financial commitment needed to sustain digital ecosystems. To ensure financial viability, both cost categories must be carefully assessed relative to per-pupil expenditure, ensuring they are both feasible and sustainable. For example, Uruguay's CEIBAL program allocates approximately 5% of its basic education budget to maintaining its digital transformation efforts, serving as a benchmark for long-term sustainability (Arias Ortiz et al., 2020b). Countries must conduct thorough cost analyses to define sustainable funding strategies that balance immediate implementation needs with long-term maintenance and adaptation.

Strategic financial planning is essential to creating programs that successfully use technology to achieve education goals. By integrating financial planning into the broader strategic vision, education policymakers can ensure efficient resource allocation and minimize the risk of funding gaps or mismatched priorities. This approach helps anticipate the full scope of costs associated with device procurement, infrastructure maintenance and connectivity, while also enabling the expansion of digital learning without exacerbating

educational inequalities. A well-structured financial strategy ensures that digital investments are cost-effective, scalable and directly contribute to improved learning outcomes and overall system efficiency.

However, financial planning for digital transformation is inherently complex. The five key enabling conditions of systemic digital transformation—digital devices, meaningful educational connectivity, digital resources and platforms, teachers’ digital and pedagogical competencies, and governance—are deeply interconnected, making budgeting particularly challenging for policymakers who may not have specialized IT expertise.

To assist education systems in identifying and estimating the costs associated with digital learning, the Inter-American Development Bank and the World Bank are developing a public tool known as the Digital Learning Cost Calculator . As part of a memorandum of understanding (MOU) signed in 2023 between the two institutions, this open-access online tool is designed to empower decision-makers to estimate costs and budget effectively for digital transformation while considering specific pedagogical goals and priorities. By incorporating key enabling conditions—such as connectivity infrastructure, device accessibility, teacher training and digital learning tools—the calculator will provide a systemic approach for estimating investment needs across different educational contexts.

As a strategic planning instrument, the Digital Learning Cost Calculator will offer crucial support for the design and implementation of digital transformation programs by providing a structured methodology for assessing needs and estimating financial requirements. These initial cost estimates will enable education authorities to engage in informed budget negotiations at both local and national levels, facilitating evidence-based decision-making. The tool will also help policymakers organize data, resources and potential intervention scenarios, improving the prioritization of investments for different regions or populations. By automating budget calculations, the calculator will enhance the efficiency of resource allocation, ensuring that funds are distributed equitably and align with educational priorities. This structured approach not only strengthens financial planning but also fosters collaboration among stakeholders, promoting a cohesive and inclusive digital learning strategy.



To assist education systems in identifying and estimating the costs associated with digital learning, the Inter-American Development Bank and the World Bank are developing a public tool known as the Digital Learning Cost Calculator.





4.2

Aligning enabling conditions with the development goals in education

Successful digital transformation in education depends on the five enabling conditions mentioned in section IV.1—digital devices, meaningful educational connectivity, digital resources and platforms, teachers’ digital and pedagogical competencies, and governance—working together. These conditions cannot operate independently, but must instead interact. Their integration is what enables technology to be meaningfully incorporated into teaching and learning.

Across the LAC region, these enabling conditions are often incomplete or entirely absent. The COVID-19 pandemic, though an emergency, highlighted these shortcomings. School closures required swift action to maintain educational continuity, yet only a few countries had the necessary conditions in place (Arias Ortiz et al., 2020b). As a result, technology adoption was largely ineffective for learning and ultimately exacerbated existing inequalities.

Reliable digital infrastructure ensures consistent access to devices and connectivity. That said, without teachers equipped to utilize these tools effectively, the impact of reliable digital infrastructure is limited. Teachers’ digital and pedagogical competencies are critical, as they must not only operate the equipment but also use it to develop innovative, personalized teaching strategies and lessons. As mediators between technology and students, teachers ensure that digital tools and platforms are being used purposefully to enhance learning outcomes. Quality digital resources and content further amplify teachers’ efforts by providing engaging, practical tools to students.

To ensure a balanced and effective digital education program, it is essential that all five enabling conditions develop at similar levels. If one lags behind—whether it be connectivity, device availability, teacher competencies, digital resources or governance—the entire system risks becoming unbalanced. If this occurs, the overall impact of technology on education will be limited. A well-coordinated approach ensures that investments and policies reinforce one another, leading to a sustainable, inclusive and transformative learning environment where technology meaningfully enhances teaching and learning for all students.

When considering integrating digital technologies into education, policymakers need to establish requirements for enabling conditions. These requirements should align with each program’s goal. Assessing the system’s readiness is critical to designing strategies that maximize the impact of digital transformation initiatives while ensuring they are both practical and cost-effective.

For example, interventions aimed at maximizing learning in the classroom hinge primarily on a relatively high levels of device availability. Platforms that enable individualized practice require that students have consistent access to devices during the practice period. This does not necessarily mean that each student must have their own device at school; students can share devices in shifts throughout the day. However, there must be enough devices to ensure that all students can use one individually, based on the desired level of dosage. Similarly, if learning platforms are not designed for offline use, the intervention will require access to meaningful connectivity at all times—which is not something that can always be ensured. Furthermore, connectivity must be ample enough to allow students to access the platform simultaneously and ensure functionalities are loading properly. The connectivity needed is different from that needed for other interventions, such as streaming a single video to complement a teacher’s instruction, which would require only one device and limited connectivity.

Another enabling condition for some learning interventions is the availability and quality of the software or platform itself. Beyond being high-quality, policymakers should collect evidence supporting a platform’s effectiveness before implementing it on a large scale. Finally, while certain interventions allow students to work relatively independently—enabling more individualized instruction and practice compared to reliance on a single teacher—teachers still need sufficient knowledge on how to navigate platforms. For example, teachers will need to know how to help students log in and troubleshoot issues as they arise. Thus, teachers’ digital skills are often essential for successful implementation.

For interventions aimed at expanding access, engagement and opportunities, one of the most critical enabling conditions is large-scale infrastructure—either digital or physical—that can support digital platforms. Having well-established and maintained public digital infrastructure to connect people, data and resources is key for data-driven insights and efficient decision making. For instance, behavioral interventions that provide information at scale require a platform containing stakeholders’ (e.g., parents’) contact information to distribute messages, such as updates on their children’s performance or the returns on education. Similarly, early warning systems depend on the centralized collection of pupil-level data to effectively deploy predictive models. For this purpose, such information typically needs to be hosted within education management and information systems (EMIS). Therefore, countries must either have this infrastructure in place or invest in its development before considering such programs.

For interventions designed to increase access to education through remote or hybrid learning from a central school, the availability of electricity and meaningful connectivity reaching the school is essential. In contrast, the need to centrally invest in devices for these interventions is generally lower, though it remains a consideration for the few devices required. Similarly, for interventions that involve or complement classroom instruction, a key enabling condition is equipping teachers with the digital and pedagogical tools necessary to effectively utilize content that is delivered remotely. Yet, policymakers must ensure that teachers are not trained or required to adapt their instruction to fit remote content in a “technology-first” approach. Instead, digital interventions should be designed to complement teachers’ existing practices, not the other way around. Nevertheless, teachers must possess the digital skills to set up and manage technology in the classroom efficiently, minimizing disruptions and ensuring it enriches instruction rather than detracting from it.

Finally, for interventions aimed at expanding efficiency within the system, a twofold enabling condition is key: high-quality, accessible digital resources and platforms, and the capacity of stakeholders (sometimes but not always teachers) to engage with these resources and platforms. For example, interventions that

seek to generate batch content (e.g., creating workbooks with numerous practice problems or structured pedagogy lessons) are limited by the actual platform that enables this process. The platform must have the appropriate algorithmic capabilities to deliver the expected outputs with the required quality. This algorithmic training must be conducted by technical experts and carefully vetted by government entities before being deployed in the field.



Policymakers must assess both the readiness of their systems and the specific requirements of each intervention, ensuring that the required enabling conditions are in place



The level of digital skills required by stakeholders in this category tends to be elevated. For interventions like the generation of workbooks that will serve the entire system, the number of users is small—often limited to a handful within the central authority— but their knowledge of the platform and its inner workings must be deep. If stakeholders working on interventions like this lack necessary technical capacities, digital transformation technologies may produce erroneous or misleading information, or may fail to function properly, ultimately falling into disuse.

In all, enabling conditions must be supported by system-level policies and resources that are tailored to the specific readiness of the education system to adopt technology. Strategic governance and institutional strengthening are essential to ensuring that these efforts are not only scalable and impactful, but also realistic and achievable.

Thus, identifying the key enabling conditions for each type of intervention and understanding the investment necessary before implementing a digital transformation initiative is crucial for its success in improving education systems. Policymakers must assess both the readiness of their systems and the specific requirements of each intervention, ensuring that the required enabling conditions are in place. By carefully evaluating these factors upfront, they can increase the likelihood of a successful and cost-effective digital transformation that meets the needs of all stakeholders involved.



4.3

Pathways for the digital transformation of education

A comprehensive approach to digital transformation requires a clear understanding of how education systems progress through different stages of digitalization. This perspective enables each system to assess its current position, define its long-term objectives and determine the most effective pathway to achieve them.

To support this process, the following table outlines a DTE progression model by organizing key indicators into three stages: access, use and integration. Each stage represents a critical milestone in the adoption of technology in education, ranging from the initial provision of digital resources to the full incorporation of technology into teaching, learning and school management. This structure is built upon the five enabling conditions described previously—digital devices, meaningful educational connectivity, digital resources and platforms, teachers’ digital and pedagogical competencies, and governance. These elements provide a structured approach for assessing the state of digitalization in schools and guiding strategic actions for development.

As stated, prior, the DTE progression model groups key indicators into three levels: access, use and integration (see Annex). Below, each level is described in detail:

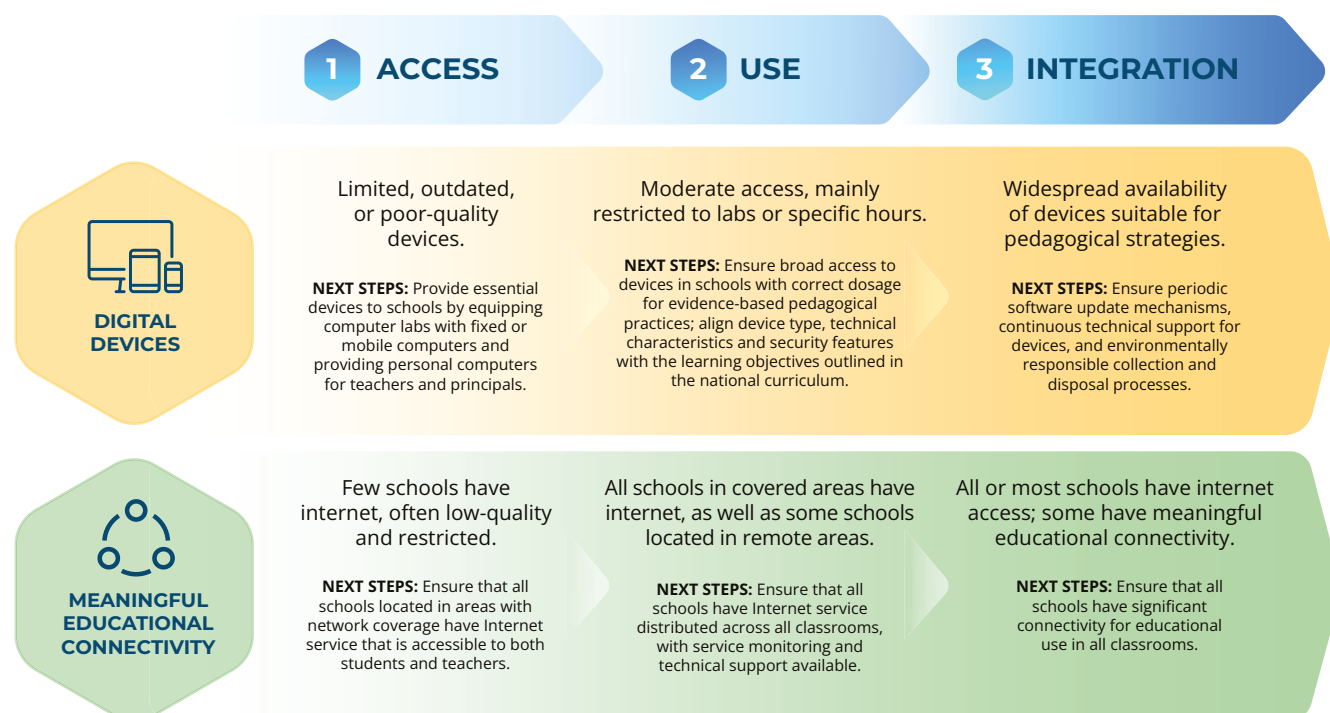
- 1 **ACCESS:** This stage focuses on ensuring the availability of digital infrastructure in an education system. Key actions include device distribution, ensuring meaningful educational connectivity and teacher training in digital skills. The primary challenges at this stage involve bridging infrastructure gaps and ensuring equitable access to technology. Key objectives include expanding device distribution, improving Internet connectivity and establishing structured professional development programs for educators.
- 2 **USE:** At this stage, the emphasis shifts to how digital tools can be actively incorporated into teaching and learning. Key actions include measuring the frequency and effectiveness of technology used by students, teachers and school leaders, as well as the implementation of digital management systems for data-driven decision-making. Key objectives include ensuring that available technology is meaningfully implemented into daily educational practices.

- 3 INTEGRATION:** This final stage signifies the full embedding of digital technology into education. Key actions include the widespread adoption of digital tools in teaching, the interoperability of learning management systems and the use of educational data for continuous improvement. Sustainability is a core focus, requiring long-term planning, technology updates and efficient digital governance mechanisms.

To ensure sustained impact and scalability, it is essential to establish standardized indicators to measure progress and outcomes. Metrics such as student access to digital devices, engagement with digital platforms, teacher training in technology-enhanced pedagogy and the use of digital tools in school administration provide valuable insights into the effectiveness of digital interventions (Trucano, 2016; UNESCO, 2023). Standardized evaluation frameworks help decision-makers track progress, identify challenges and make data-driven adjustments to policies and investments (OECD, 2021). Without consistent measurement, digital transformation efforts risk inefficiencies, fragmentation and financial instability, limiting their long-term sustainability (World Bank, 2020).

The progression path outlined in Table 3 offers a structured yet flexible guide to this process. As such, it can serve as a practical tool for policymakers hoping to design evidence-based strategies for digital education. By articulating clear stages and measurable objectives, this model enables decision-makers to identify priority areas for intervention and equips them with a comprehensive set of indicators to monitor progress on key dimensions aligned with their evidence-based policy goals. Furthermore, it ensures that DTE evolves in a systematic and coherent manner, tailored to the specific needs and capacities of each education system.

Table 3. Pathways to DTE



1 ACCESS

2 USE

3 INTEGRATION



TEACHERS' DIGITAL AND PEDAGOGICAL COMPETENCIES

No standards for technology use; teachers lack minimum digital competency levels.

NEXT STEPS: Develop a framework for teachers' competencies in using technology in the classroom; include training programs and courses in DTE-related areas in the professional development offerings for in-service teachers, making them a requirement or a contributing factor for teachers' promotion and career advancement.

Most teachers trained in at least one DTE area, achieving adaptation and integration levels of digital competency.

NEXT STEPS: Ensure that the vast majority of teachers receive training in multiple DTE-related areas; ensure that initial teacher training programs include evidence-based pedagogical integration of technology.

Many teachers achieve adaptation or higher competency levels.

NEXT STEPS: Ensure that all teachers have the competencies to integrate technological tools into their students' learning experiences, promoting and teaching their ethical and responsible use; teachers should use technology to evaluate and analyze information on their students' performance.



DIGITAL RESOURCES, PLATFORMS, AND CONTENT

Minimal access to platforms; basic tools with limited functionality.

NEXT STEPS: Establish a repository of simple, high-quality educational platforms and pedagogical content that are relevant to the educational system's curriculum and context; ensure free access for schools and educational communities.

Widespread use of simple platforms and digital resources; no centralized repository of mid-level complexity tools.

NEXT STEPS: Implement a learning management system (LMS) with mid-level complexity content and platforms, including personalization options and the ability to generate data for learning analysis and student progress tracking.

Several schools use validated and contextualized resources integrated into the Learning Management System (LMS).

NEXT STEPS: Ensure that the vast majority of schools use the provided LMS; LMS should support mid- to high-complexity content and platforms (incorporating assessment tools, artificial intelligence and immersive experiences).



GOVERNANCE

No strategic plan for DTE; weak or non-existent information systems.

NEXT STEPS: Establish a dedicated unit or team to design and implement DTE strategies; create or strengthen information systems in terms of relevance, quality and efficiency; develop a short-, medium-, and long-term plan for DTE implementation.

Disconnected information systems; no official DTE roadmap; the curriculum does not cover digital skills.

NEXT STEPS: begin the digitization of key processes for educational management*; develop educational curriculum that integrate digital competencies; establish processes for the periodic generation of key monitoring indicators for the education system

High-quality, efficient systems; key education processes digitized; curriculum includes digital skills.

NEXT STEPS: Achieve interoperability of information systems for educational management processes, enable digital administrative educational transactions (such as student enrollment, sick leave requests and permissions), and establish a digital dashboard for monitoring and analyzing key indicators of the educational system.

* See: <https://publications.iadb.org/es/los-sistemas-de-informacion-y-gestion-educativa-siged-de-america-latina-y-el-caribe-la-ruta-hacia>

5. Conclusion





As education systems navigate the rapid advancement of digital technologies and AI, it is essential to move beyond enthusiasm and adopt a strategic, evidence-based approach to their integration. While technology offers significant potential to enhance learning, streamline education management and expand access, its impact depends on how it is implemented and whether key enabling conditions are met. Lessons from past initiatives highlight the importance of ensuring equity, providing adequate teacher support and fostering strong governance. With AI's growing role in education, thoughtful policy design and continuous evaluation are crucial to maximizing benefits while mitigating risks.

The three main takeaways from this analysis provide guiding principles for policymakers and stakeholders to shape digital transformation efforts that are effective, inclusive and sustainable.

First, implementation requires a balanced and systemic approach.

The five enabling conditions— digital devices, meaningful educational connectivity, teacher competencies, digital resources and governance—must be developed in parallel to create a cohesive and effective digital learning ecosystem. A fragmented approach risks limiting the impact of digital transformation efforts.

- > Equitable access must be a priority to prevent widening educational disparities, ensuring all students, regardless of socioeconomic background, have reliable access to meaningful connectivity, digital devices and high-quality learning resources. At the core of digital learning, platforms and resources must be curriculum-aligned, inclusive and adaptive. AI should be used strategically to personalize learning, provide real-time feedback and enhance accessibility for diverse student needs.
- > Beyond infrastructure and content, teacher and education leader support is essential for meaningful technology integration. Educators and policymakers need continuous training and resources to effectively incorporate digital tools into teaching and decision-making. Additionally, strong governance and sustainable financing are critical for long-term success. Governments, the private sector, academia, and civil society must collaborate to establish clear roles, accountability frameworks and financial strategies that go beyond initial investments, ensuring ongoing maintenance, teacher training and system upgrades for the scalability and continuity of digital education initiatives.

Second, ensure an appropriate and purposeful use of AI in education.

AI should be deployed to complement and enhance traditional teaching methods. AI can help personalize learning, automate administrative tasks and improve decision-making, but it should not replace essential human interactions. Furthermore, the use of AI must align with pedagogical goals and be guided by the needs of students and teachers.

- > Despite its potential, the benefits of AI for both students and teachers, as well as the long-term impact of AI in education remain insufficiently studied. This highlights the need for rigorous evaluation and research. Policymakers should invest in pilot programs, data-driven assessments and long-term impact studies to ensure AI-supported solutions lead to measurable improvements in learning outcomes. Additionally, ethical considerations and data privacy must be prioritized, as AI raises concerns about student data security, algorithmic bias and transparency. Establishing clear legal and governance frameworks is essential for protecting learners while fostering responsible AI adoption in education.

Finally, developing both learning and future-ready skills.

Digital tools and AI should not only support traditional learning but also help students develop essential 21st-century skills that prepare them for an evolving workforce. These skills include critical thinking, problem-solving, digital literacy and adaptability.

- > Technological skills are projected to grow in importance more rapidly than any other type of skill by 2030, and among these, AI and big data top the list as the fastest-growing skills, followed closely by networks and cybersecurity, and technological literacy (World Economic Forum, 2025). This trend underscores the critical importance of AI proficiency for individuals navigating the modern workforce.

As AI and digital tools become increasingly integrated into education and the workforce, ensuring students develop the skills to effectively use and interact with AI is essential. Students must not only learn how to use AI-powered tools but also understand their limitations, assess the reliability of AI-generated content and apply ethical reasoning in digital interactions. Developing these competencies will empower learners to use AI responsibly, remain competitive in the workforce and actively contribute to a rapidly changing society. In turn, students will not just become passive consumers of technology but informed and capable participants in the digital age. Achieving a successful integration of technology and AI in education systems in Latin America and the Caribbean is a first step towards that.

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Annex

Table A1. Pathways to DTE and key indicators

INITIAL INDICATORS: ACCESS

ENABLING CONDITION	INDICATORS	PROGRESS PATHS
 Digital devices	- # of digital devices per student/teacher in schools.	Early path characteristics: Limited access to devices in schools; low-quality devices; devices in poor condition or with outdated software.
	- # or % of schools equipped with up-to-date and functional computer labs	Next steps: Provide essential devices to schools by equipping computer labs with fixed or mobile computers and providing personal computers for teachers and principals.
 Meaningful educational connectivity	- # or % of students and teachers with access to Internet connectivity in schools	Early path characteristics: Few schools have Internet access; connectivity is poor quality (low speed or high intermittency); connectivity is only available in certain areas of the school (e.g. the principal's office).
	- # or % of schools with Internet service in at least one of their classrooms	Next steps: Ensure that all schools located in areas with network coverage have Internet service that is accessible to both students and teachers.
 Teachers' digital and pedagogical competencies	- # of courses or training offered to teachers on pedagogical practices that effectively incorporate technology and digital tools.	Early path characteristics: There is no framework or standards for teachers' competencies in using technology in the classroom; the teaching staff is mostly at an initial level of technological competency with early exposure to and familiarization with the three key areas of DTE) outlined in the Edutec Guide: pedagogy, digital citizenship and professional development, as outlined in the outlined in IDB's Edutec Guide (see descriptors at: https://publications.iadb.org/es/herramienta-de-integracion-de-tecnologias-digitales-en-los-sistemas-educativos-marco-conceptual).
	- # of courses or training offered to school principals and educational leaders on managing the digital transformation of education	Next steps: Develop a framework for teachers' competencies in using technology in the classroom; include training programs and courses in DTE-related areas in the professional development offerings for in-service teachers, making them a requirement or a contributing factor for teachers' promotion and career advancement.
 Digital resources, platforms and content	- # or % of students and teachers with access to educational and learning management platforms	Early path characteristics: Little or no access to educational platforms; only some schools use basic platforms that are simple to use, require little or no configuration, lack personalization options and can be used fully or partially offline
	- # of schools equipped with digital content platforms	Next steps: Establish a repository of simple, high-quality educational platforms and pedagogical content that are relevant to the educational system's curriculum and context; ensure free access for schools and educational communities.
 Governance	- Education system with information systems featuring unique student identifiers.	Early path characteristics: There is no strategic plan for implementing DTE processes; no dedicated unit or team oversees the DTE processes; information systems are either non-existent or in their early stages; there is no established protocol for data collection, information flow or information quality validation; the system does not have unique identifiers for students and/or schools
	- Education system with a strategic unit or agency to manage the digital transformation of education.	Next steps: Establish a dedicated unit or team to design and implement DTE strategies; create or strengthen information systems in terms of relevance, quality and efficiency; develop a short-, medium-, and long-term plan for DTE implementation.

INTERMEDIATE INDICATORS: USE

ENABLING CONDITION	INDICATORS	PROGRESS PATHS
 Digital devices	- # or % of students and teachers that have used the school's computer lab.	Intermediate path characteristics: Moderate access to devices in schools; few devices are available for the number of students; access is restricted in a way that does not serve pedagogical goals to specific hours or only in computer labs.
	- # or % of students and teachers conducting educational activities with digital devices.	Next steps: Ensure broad access to devices in schools with correct dosage for evidence-based pedagogical practices; align device type, technical characteristics and security features with the learning objectives outlined in the national curriculum.
 Meaningful educational connectivity	- # or % of students, teachers and principals that can access the Internet at least x times per week at schools	Intermediate path characteristics: All schools are located in areas with network coverage and as many schools as possible located in more remote areas have Internet service.
	- # or % of schools with Internet access in all classrooms.	Next steps: Ensure that all schools have Internet service distributed across all classrooms, with service monitoring and technical support available.
 Teachers' digital and pedagogical competencies	- # or % of teachers that have successfully completed courses or training on pedagogical practices that incorporate technology and digital citizenship.	Intermediate path characteristics: Most teachers have received training in at least one area related to DTE and have reached the levels of adaptation and integration in the key DTE areas outlined in the Edutec Guide: Pedagogy, Digital Citizenship, and Professional Development (see descriptors at: https://publications.iadb.org/es/herramienta-de-integracion-de-tecnologias-digitales-en-los-sistemas-educativos-marco-conceptual)
	- # or % of principals and educational leaders that have successfully completed courses or training on managing DTE.	Next steps: Ensure that the vast majority of teachers receive training in multiple DTE-related areas; ensure that initial teacher training programs include evidence-based pedagogical integration of technology.
 Digital resources, platforms and content	- # or % of students and teachers that use educational and learning management platforms.	Intermediate path characteristics: There is widespread use of simple platforms and digital pedagogical materials; there is no centralized repository or curation of mid-level complexity platforms; the use of platforms that enable personalized learning is limited.
	- # or % of students or teachers that consult digital content platforms.	Next steps: Implement a learning management system (LMS) with mid-level complexity content and platforms, including personalization options and the ability to generate data for learning analysis and student progress tracking.
 Governance	- Education system with at least one digitalized management process (e.g., enrollment, budget allocation, teacher assignment, license and substitute management, payroll processing).	Intermediate path characteristics: Existing information systems are disconnected; there is no official planning document or roadmap for DTE; there are no curricular or graduation requirements aligned with digital competencies.
	- Officials from the secretariat and educational networks use strategic dashboards for school management	Next steps: begin the digitization of key processes for educational management (see: https://publications.iadb.org/es/los-sistemas-de-informacion-y-gestion-educativa-siged-de-america-latina-y-el-caribe-la-ruta-hacia); develop educational curriculum that integrate digital competencies; establish processes for the periodic generation of key monitoring indicators for the education system

ADVANCED INDICATORS: INTEGRATION

ENABLING CONDITION	INDICATORS	PROGRESS PATHS
 Digital devices	- # or % of students or teachers conduct activities in computer labs at least X times per week.	Advanced path characteristics: Schools have a wide provision of devices for principals, teachers and students, along with appropriate spaces for their use in classrooms. The devices are suitable for teachers' evidence-backed pedagogical strategies.
	- # or % of students or teachers have access to technical support for the repair and ecological final disposal of the devices.	Next steps: ensure periodic software update mechanisms, continuous technical support for devices, and environmentally responsible collection and disposal processes.
 Meaningful educational connectivity	- # or % of schools that have significant educational connectivity in at least X% of classrooms at least X% of school days.	Advanced path characteristics: All or most schools have Internet service distributed across all classrooms; some have significant connectivity for educational uses.
		Next steps: Ensure that all schools have significant connectivity for educational use in all classrooms.
 Teachers' digital and pedagogical competencies	- # or % of teachers integrate technological and digital citizenship tools into their pedagogical practices.	Advanced path characteristics: A large proportion of teachers have reached the levels of adaptation and integration in the key DTE areas outlined in the Edutec Guide: Pedagogy, Digital Citizenship, and Professional Development (see descriptors at: https://publications.iadb.org/es/herramienta-de-integracion-de-tecnologias-digitales-en-los-sistemas-educativos-marco-conceptual)
	- # or % of teachers that use digital tools to collect and analyze student performance information.	Next steps: Ensure that all teachers have the competencies to integrate technological tools into their students' learning experiences, promoting and teaching their ethical and responsible use; teachers should use technology to evaluate and analyze information on their students' performance.
 Digital resources, platforms and content	- # or % of students or teachers that use educational and learning management platforms at least X times per month.	Advanced path characteristics: Some schools use the content and platforms integrated into the provided learning management system (LMS); the platforms and content have been validated, contextualized and adapted to the schools' population.
	- # or % of students or teachers that consult digital content at least X times per month.	Next steps: Ensure that the vast majority of schools use the provided LMS; LMS should support mid- to high-complexity content and platforms (incorporating assessment tools, artificial intelligence and immersive experiences).
 Governance	- Education system with at least X digitized management processes interoperating (e.g., enrollment, budget allocation, teacher assignment, license and substitute management, payroll processing).	Advanced path characteristics: Information systems meet high standards of quality, relevance and efficiency; most key processes for educational management are digitized; the curriculum includes digital skills and competencies.
	- Education system has implemented a DTE curriculum reform.	Next steps: Achieve interoperability of information systems for educational management processes, enable digital administrative educational transactions (such as student enrollment, sick leave requests and permissions), and establish a digital dashboard for monitoring and analyzing key indicators of the educational system.

